Klamath River Modeling Framework to Support the PacifiCorp Federal Energy Regulatory Commission Hydropower Relicensing Application

- Appendices -

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A Klamath River Water Quality Modeling Framework[1]

A.1 Introduction

As identified in subtask 1.3, Water Quality Analysis and Modeling Needs Assessment and Scoping Process, the objectives of water quality analysis and modeling are to:

- Determine what analysis and modeling tools are needed to assess Project water quality effects and compliance with water quality standards and objectives
- Determine the appropriate geographic scope for the needed analysis and modeling tools
- Clarify specifically how water quality compliance will be determined for the Project using such tools
- Develop plans for completing this analysis and modeling
- Ensure appropriate analytical coordination with larger-scale analyses and modeling that PacifiCorp assumes will be conducted by the agencies as a key part of TMDL water quality
- management planning in the basin
- Support subsequent assessment (including in other studies or during license application preparation) of the Project's potential effects on water quality and possible measures to protect, enhance, and mitigate where necessary.

In response to these objectives, as well as feedback from other stakeholders and interested parties in the Klamath River system a modeling framework has been developed, and is presented herein.

A.2 Klamath River Modeling Framework

The Klamath River system from Upper Klamath Lake to below Iron Gate Dam is a complex of river reaches and reservoirs. There are four major impoundments: Lake Ewuana/Keno Reservoir, JC Boyle Reservoir, Copco Reservoir, and Iron Gate Reservoir. Free-flowing river reaches occur between the impoundments with the exception of Copco Dam and Iron Gate Reservoir (Figure 1).

The diversity among the reservoir operations, inflows and diversions, morphology, and water quality characteristics is considerable. The river reaches vary in a similar manner. To effectively represent the flow and water quality characteristics of these reservoir and river reaches the models must be able to accommodate a wide range of conditions. Outlined herein are the general characteristics of each reservoir and river reach, the selected model, modeling parameters, and data needs. The framework of models is adaptable to modeling system components individually or as an integrated system, and is capable of representing a without project condition. An appendix includes descriptions of the various model attributes.

[1] This is the original framework submitted as part of subtask 1.3. Modifications have been made. Although not comprehensive, notes have been added to this section to identify significant changes.

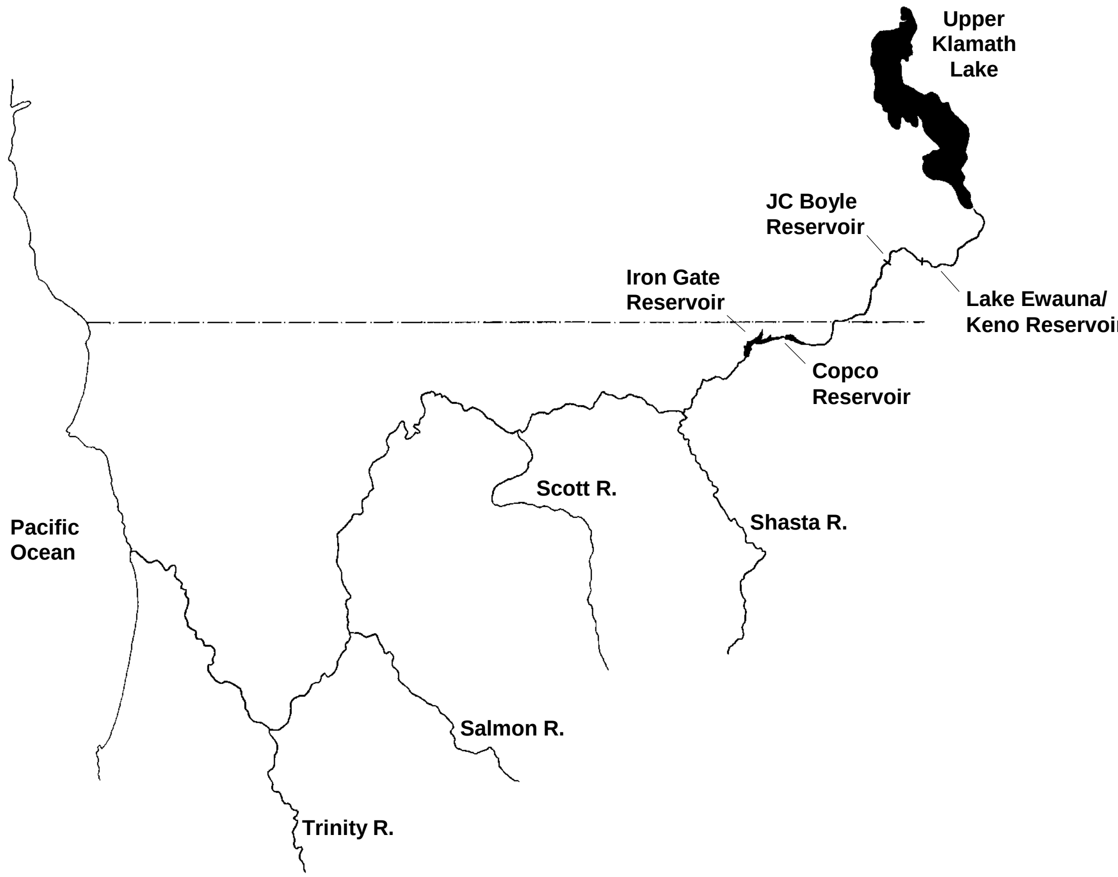


Figure 1. Klamath River System

A.2.1 Models

Four models are proposed for use to represent the various reservoir and river reaches in the Klamath Basin throughout the study area: CE-QUAL-W2, WQRRS[2], RMA-2 and RMA-11. These models are full water quality models capable of simulating water temperature as well as a wide range of water quality parameters in reservoirs and rivers. Although there are a range of models available, these were selected for several reasons

- They are physically-based numerical models capable of simulating a wide range of water quality conditions under dynamic conditions
- The models have been widely applied and have been widely tested
- They have been or are actively being used in the Klamath Basin
- The codes are not proprietary and are thus readily available for review

The reservoir models that will be used include the U.S. Army Corps of Engineers (USACE) model CEQUAL-W2, and the USACE model WQRRS. CEQUAL-W2 is a two dimensional, longitudinal and vertical representation of a water body. WQRRS is a

[2] WQRRS was not selected as a final model for includion in the modeling framework. CE-QUAL-W2 was used for all reservoir systems.

one-dimensional vertical representation for stratified or well-mixed reservoirs. The river reaches will be modeled with a set of models, RMA-2 will be used to represent the hydrodynamic flow regime and the output (velocity, depth, etc.) will be used as input for the stream water quality model RMA-11.

The reservoir models will run on daily and/or sub-daily time steps. Certain reaches have been identified as requiring time steps on the order of an hour (e.g., JC Boyle full flow reach).

Model descriptions and general information is included in the appendix. It is presumed that these more complex models will be supported with simpler process-based or statistical models.

Interfacing the Models

Modeling the Klamath River reaches and reservoirs will be completed using different models for reservoir and river reaches. The process of interfacing or linking the models is a matter of writing separate computer programs to process the output from one model (e.g., river model) such that it forms the input to the subsequent model (e.g., reservoir model): a necessary, but straightforward task[3]. The end result is a model framework that can be used to examine individual reaches, or larger sections of the river and reservoir system.

A.2.2 Analyses

The system will be modeled for flow and water quality throughout the study area. Table 1 identifies the specific parameters that will be simulated in each reach. Physical, chemical, or biological information is unavailable or system response unknown in certain reaches. The selected models are capable of addressing these issues and can be used to test sensitivity of these processes and parameters as well as identify the need for additional data collection.

[3] This task was not funded, thus no formal software was developed to interface the models. Data transfer was done via spreadsheet manipulation.

Table 1 Water quality parameters selected for simulation in each reach of the study area, and selected model for sub-reach

	Flow/ Stage	Tw	DO	Nutrients[1]	BOD	SOD	Phyto-plankton	Attached Algae[2]	Model
Link R	●	●	●	●	●		TBD	●	RMA-2/11
Lake Ewauna/Keno	●	●	●	●	●	●	●		CE-QUAL-W2
Keno Dam to JC Boyle	●	●	●	●	●		TBD	●	RMA-2/11
JC Boyle	●	●	●	●	●	●	●		WQRRS[3]/ RMA-2/11
Bypass Reach	●	●	●	●	●			●	RMA-2/11
JC Boyle Full Flow Reach	●	●	●	●	●			●	RMA-2/11
Copco Reservoir	●	●	●	●	●	●	●		WQRRS[3]
Iron Gate Reservoir	●	●	●	●	●	●	●		WQRRS[3]
Klamath River below IGD	●	●	●	●	●			●	RMA-2/11

[1] Nutrients: Org N, NH_4^+, NO_2^-, NO_3^-, Org P, PO_4^{3-} (models may represent different collections of nutrient processes, all models include dominant inorganic forms)

[2] Attached algae modeling will be completed if required to simulate system response. In some of the short reaches it may not be necessary

[3] Final model applied to these systems was CE-QUAL-W2 (Update: Change from original framework)

Other water quality processes may be represented as well, e.g., specific conductance.

A.3 Model Representations and Required Information

A brief description of each reach, modeling approach, data requirements, and additional field studies for all of the study reaches are outlined below. Much of the data required to implement, test, and calibrate/validate the model will come from existing data sets. Additional seasonal monitoring and multiple day synoptic surveys are planned to provide other necessary information.

A.3.1 Link River

The Link River reach extends 1.2 miles from Link Dam to Lake Ewauna. This short river reach has no tributaries and a moderate gradient. Flows are generally stable, but can vary over short time periods. Water quality in the reach is dominated by upstream Upper Klamath Lake conditions. The transit time is on the order of hours.

A.3.1.1 Modeling Approach

This river reach will be modeled with river models RMA-2 (flow) and RMA-11 (water quality).

A.3.1.2 Data Requirements

Meteorological Conditions

- Klamath Falls (solar radiation, dry bulb temperature, wet bulb temperature, wind speed, atmospheric pressure)

Geometry

- channel cross sections (estimate, previous field work)
- bed slope (USGS)
- UTM or Lat/Long description of reach (USGS, GIS)
- locations of inputs (accretions, tributaries, and return flows) and withdrawals (diversions), if any (USGS, GIS)

Initial Conditions

- initial algal biomass if benthic algae is modeled
- model will be used to formulate initial flow and water quality conditions

Boundary Conditions and Calibration/Validation Data

Model calibration and validation will use data from the Link River above Lake Ewauna site, as well as the appropriate powerhouse return flow. Boundary conditions and calibration/validation data are summarized in Table 2.

Table 2 Link River boundary conditions and calibration/validation data

	Flow/ Stage	Tw	DO	Nutrients[1]	BOD	Algae[2]	Other[3]	Boundary Condition	Cal/Val Site
Link Dam	H/D	H	H/D	G	G	G		Yes	No
Powerhouse #1 and #2[4]	H/D	H	H/D	G	G	G		Yes	No
Link R ab. Lake Ewauna	H/D	H	H/D	G				Yes[5]	Yes

[1] Nutrients: Org N, NH_4^+, NO_2^-, NO_3^-, Org P, PO_4^{3-} (models may represent different collections of nutrient processes, all models include dominant inorganic forms)

[2] Benthic algae modeling will be completed if required to simulate system response. Phytoplankton may be represented in this reach to reflect influx from Upper Klamath Lake.

[3] Other water quality constituents may be represented as well, e.g., specific conductance.

[4] Powerhouse return flow quality will be estimated using Link Dam data

[5] A flow or stage boundary condition will be required at this location

Sampling Frequency:

H – hourly

D – Daily

M – Monthly

G – Grab sample (frequency varies from sub-daily to monthly)

A.3.1.3 Additional Field Studies

- Synoptic surveys to characterize conditions for model calibration and validation

A.3.2 Link River to Keno Dam

Lake Ewauna/Keno Reservoir are formed by Keno Dam. Lake Ewauna is a wide, relatively shallow body of water from about RM 251 to 253, while Keno reservoir is a narrower reach between RM 233 and 251. The impoundment is approximately 20 miles in length and served both as a supply and discharge point for municipal, industrial, and agricultural uses. This reach experiences a wide range of water quality conditions and is one of the more complex and least understood system in the study area.

A.3.2.1 Modeling Approach

Lake Ewauna/Keno Reservoir will be modeled with CE-QUAL-W2.

A.3.2.2 Data Requirements

Meteorological Conditions

- Klamath Falls (solar radiation, dry bulb temperature, wet bulb temperature, wind speed, atmospheric pressure)

Geometry

- Bathymetric survey of reach (PacifiCorp)
- UTM or Lat/Long description of reach (USGS)
- locations of inputs (accretions, tributaries, and return flows) and withdrawals (diversions), (USGS)

Initial Conditions

- model will be used to formulate initial flow and water quality conditions

Boundary Conditions and Calibration/Validation Data

Model calibration and validation will use data at a minimum of five locations within the study reach. Boundary conditions and calibration/validation data are summarized in Table 2.

A.3.2.3 Additional Field Studies

The US Bureau of Reclamation will be sampling Lake Ewauna and Keno Reservoir at two week intervals at roughly a dozen locations. It is expected that these data may be augmented with additional studies, possibly including sediment analysis and phytoplankton studies. These special studies are still under consideration.

Table 3 Lake Ewauna/Keno Reservoir boundary conditions and calibration/validation data

	Flow/ Stage	Tw	DO	Nutrients[1]	BOD	Algae	Other[2]	Boundary Condition	Cal/Val Site
Link R ab. Lake Ewauna	H/D	H	H	G	G	G		Yes	No
Municipal and Industrial Use	D							Yes	No
Municipal and Industrial Discharge	D	D	D	D				Yes	No
Agricultural Diversion	D							Yes	No
Agricultural Discharge	D	H/D	H/D	G				Yes	No
Lake Ewauna[3]	D	H	H	G		G			Yes
Miller Island	D	H	H	G		G			Yes
Teeters Landing	D	H	H	G		G			Yes
Additional sites[4]	D	H	H	G		G			Yes
Keno Dam	D	H	H	G		G		Yes[5]	Yes

[1] Nutrients: Org N, NH_4^+, NO_2^-, NO_3^-, Org P, PO_4^{3-} (models may represent different collections of nutrient processes, all models include dominant inorganic forms)

[2] Other water quality constituents may be represented as well, e.g., specific conductance.

[3] USBR has 3 sites in Lake Ewauna that may be used to support model applications

[4] USBR has several additional sites between Lake Ewauna and Keno Dam that may be used for model application

[5] A flow or stage boundary condition will be required at this location

Sampling Frequency:

H – hourly

D – Daily

M – Monthly

G – Grab sample (frequency varies from sub-daily to monthly)

A.3.3 Keno Dam to JC Boyle Reservoir

The Klamath River between Keno Dam and JC Boyle Reservoir is a characterized by a steep gradient with moderate to high velocities. This relatively short river reach has no major tributaries but experiences an undetermined, but probably small spring flow accretion. There are no major withdrawals or discharges into the reach. Although Keno Dam releases are relatively constant (essentially operated as a “run-of-river” facility), short-term fluctuations in flow are evident at times. Such fluctuations are due mainly to the effects of diversions from and return flows to Lake Ewauna/Keno Reservoir in response to irrigation operations.

The reach is dominated by upstream water quality. Further, the reach is relatively short, with transit time being well under one day. Although the diurnal range of temperature and dissolved oxygen is somewhat moderated by releases from Keno Reservoir, by the time water reaches the end of this reach there is a diurnal signal is observable. Overall, little is known about the water quality response of this reach.

A.3.3.1 Modeling Approach

This river reach will be modeled with river models RMA-2 (flow) and RMA-11 (water quality).

A.3.3.2 Data Requirements

Meteorological Conditions

- Klamath Falls (solar radiation, dry bulb temperature, wet bulb temperature, wind speed, atmospheric pressure)

Geometry

- channel cross sections (estimate, previous field work)
- bed slope (USGS)
- UTM or Lat/Long description of reach (USGS, GIS)
- locations of inputs (accretions, tributaries, and return flows) and withdrawals (diversions), if any (USGS, GIS)

Initial Conditions

- initial algal biomass if benthic algae is modeled
- model will be used to formulate initial flow and water quality conditions

Boundary Conditions and Validation Data

Calibration and validation of the model will be completed using data from the site above JC Boyle Reservoir. Boundary conditions and calibration/validation data are summarized in Table 4.

Table 4 Keno Dam to JC Boyle Reservoir boundary conditions and calibration/validation data

	Flow/ Stage	Tw	DO	Nutrients[1]	BOD	Algae[2]	Other[3]	Boundary Condition	Cal/Val Site
Keno Dam	H	H	H	G	G	G		Yes	No
Accretions	D/W	D/G	G	G	G*	G*		Yes	No
KR above JC Boyle	H	H	H	G				Yes[4]	Yes

[1] Nutrients: Org N, NH_4^+, NO_2^-, NO_3^-, Org P, PO_4^{3-} (models may represent different collections of nutrient processes, all models include dominant inorganic forms)

[2] Benthic algae modeling will be completed if required to simulate system response.

[3] Other water quality constituents may be represented as well, e.g., specific conductance.

[4] A flow or stage boundary condition will be required at this location

Sampling Frequency:

H – hourly

D – Daily

M – Monthly

G – Grab sample (frequency varies from sub-daily to monthly)

A.3.3.3 Additional Field Studies

- synoptic water quality study (3 periods – 3 days each): to characterize short-term variability in the reach and for model calibration and validation
    - continuously monitoring probes (physical parameters - hourly) at the top and bottom of reach
    - grab samples 2 times once day for three days at the top and bottom of reach to coincide with the continuously monitoring probe deployment
- field reconnaissance to identify potential spring flow accretion location, quantity and quality

A.3.4 JC Boyle Reservoir

The J.C. Boyle reservoir reach includes the portion of the mainstem Klamath River from J.C. Boyle dam (RM 224.7) to the upper end of the J.C. Boyle reservoir (RM 228) near the mouth of Spencer Creek. The reservoir is relatively shallow and typically experiences a short residence time and is prone to weak stratification.

A.3.4.1 Modeling Approach

This reach can be modeled in two ways. It can be represented in WQRRS as a weakly stratified to mixed reservoir system. It also can be modeled as a slow deep river using the river models RMA-2 (flow) and RMA-11 (water quality). Both approaches will be explored to potentially investigate both longitudinal and vertical characteristics of the water body. (Ultimately CE-QUAL-W2 was the selected model for this application. This is an update: Change from original framework.)

A.3.4.2 Data Requirements

Meteorological Conditions

- Klamath Falls (solar radiation, dry bulb temperature, wet bulb temperature, wind speed, atmospheric pressure)

Geometry

- Bathymetric survey of reach (PacifiCorp)
- UTM or Lat/Long description of reach (USGS)
- locations of inputs (accretions, tributaries, and return flows) and withdrawals (diversions), (USGS)

Initial Conditions

- initial reservoir stage
- initial water quality profile
- initial organic sediment mass
- for river models, initial condition will be developed using the models

Boundary Conditions and Validation Data

For WQRRS calibration and validation will utilize data from the vertical profile site JC Boyle Dam. If the river models are implemented, data from synoptic surveys (to be completed) will be necessary. Both models would be calibrated to effectively simulate outflow conditions as well. Boundary conditions and calibration/validation data are summarized in Table 5.

Table 5 JC Boyle Reservoir boundary conditions and calibration/validation data

	Flow/ Stage	Tw	DO	Nutrients[1]	BOD	Algae	Other[2]	Boundary Condition	Cal/Val Site
KR above JC Boyle	H	H	H	G	G	G		Yes[3]	No
JC Boyle Reservoir Profile/Synoptic	D	H/M (P)	M (P)	M (2 Depths)	M (2 Depths)	M (2 Depths)		No	Yes
JC Boyle Release (below Boyle)	H/D	H/D	G	G	G	G		Yes[4]	Yes

[1] Nutrients: Org N, NH_4^+, NO_2^-, NO_3^-, Org P, PO_4^{3-} (models may represent different collections of nutrient processes, all models include dominant inorganic forms)

[2] Other water quality constituents may be represented as well, e.g., specific conductance.

[3] Shovel Creek and other accretions may be combined with Klamath River above JC Boyle

[4] A flow or stage boundary condition will be required at this location

Sampling Frequency:

H – hourly

D – Daily

M – Monthly, M(P) refers to a monthly profile

G – Grab sample (frequency varies from sub-daily to monthly)

A.3.4.3 Additional Field Studies

- synoptic water quality study (3 periods – 3 days each): to characterize short-term variability in the reach and for model calibration and validation
    - continuously monitoring probes (physical parameters) at the headwaters and in the reservoir release
    - monitor vertical profiles of temperature, dissolved oxygen, pH, specific conductance, and oxidation-reduction potential (ORP) at two intermediate points in the reservoir twice per day
    - grab samples 1 time per day for 3 days at the headwaters and in the reservoir release, as well as two intermediate points (coincident with the above noted profiles). These grab samples should occur at two depths in the reservoir, corresponding to roughly 1meter deep and 1 meter off the bottom.
    - algal species identification
- sediment sampling to determine sediment oxygen demand (SOD) and possibly nutrient release. One set of samples (cores) during the summer season
- collect samples to identify algal species
- field reconnaissance to quantify potential accretions and depletions to/from reservoir (e.g., Spencer Creek)

A.3.5 JC Boyle Bypass Reach

The JC Boyle bypass reach is 4.3 miles long, extending from JC Boyle Dam to the JC Boyle Powerhouse. Minimum FERC releases from JC Boyle dam are 100 cfs. Although there are no major tributaries, there are significant spring flow accretions. The reach is steep and transit time appears to be on the order of hours. Spring flow accretion quantity and quality, as well as location are under represented in available data.

A.3.5.1 Modeling Approach

This river reach will be modeled with river models RMA-2 (flow) and RMA-11 (water quality).

A.3.5.2 Data Requirements

Meteorological Conditions

- Klamath Falls (solar radiation, dry bulb temperature, wet bulb temperature, wind speed, atmospheric pressure)

Geometry

- channel cross sections (estimate, previous field work)
- bed slope (USGS)
- UTM or Lat/Long description of reach (USGS, GIS)
- locations of inputs (accretions, tributaries, and return flows) and withdrawals (diversions), if any (USGS, GIS)

Initial Conditions

- initial algal biomass if benthic algae is modeled
- model will be used to formulate initial flow and water quality conditions

Boundary Conditions and Validation Data

Calibration and validation of the model will be completed using data from the site above JC Boyle penstock return. Boundary conditions and calibration/validation data are summarized in Table 6.

A.3.5.3 Additional Field Studies

- synoptic water quality study (3 periods – 3 days each): to characterize short-term variability in the reach and for model calibration and validation
    - continuously monitoring probes (physical parameters - hourly) at the top and bottom of reach
    - grab samples 1 time per day for at the top and bottom of reach to coincide with the continuously monitoring probe deployment
- field reconnaissance to locate spring inflow locations and to collect representative water quality samples
- estimate spring inflow quantity in bypass reach

Table 6 JC Boyle Dam to penstock return (bypass reach) boundary conditions and calibration/validation data

	Flow/ Stage	Tw	DO	Nutrients[1]	BOD	Algae[2]	Other[3]	Boundary Condition	Cal/Val Site
JC Boyle Release to KR	H/D	H/D	G	G	G	G		Yes	No
Accretions	D	D/G	G	G	G	G		Yes	No
KR above Penstock Return	H/D	H	H	G	G	G		Yes[4]	Yes

[1] Nutrients: Org N, NH_4^+, NO_2^-, NO_3^-, Org P, PO_4^{3-} (models may represent different collections of nutrient processes, all models include dominant inorganic forms)

[2] Benthic algae modeling will be completed if required to simulate system response.

[3] Other water quality constituents may be represented as well, e.g., specific conductance.

[4] A flow or stage boundary condition will be required at this location

Sampling Frequency:

H – hourly

D – Daily

M – Monthly

G – Grab sample (frequency varies from sub-daily to monthly)

A.3.6 JC Boyle Full Flow[4] Reach

The JC Boyle bypass reach is 16.4 miles long, extending from JC Boyle penstock return to the Copco Reservoir. During peaking periods flow rates vary on a subdaily basis between about 350 cfs (inflow from the bypass reach) to approximately 3000 cfs. Several small tributaries occur in this reach, the largest of which is Shovel Creek. The reach is steep and experiences a highly dynamic flow regime. The transit time is typically less than a day.

A.3.6.1 Modeling Approach

This river reach will be modeled with river models RMA-2 (flow) and RMA-11 (water quality).

A.3.6.2 Data Requirements

Meteorological Conditions

- Klamath Falls (solar radiation, dry bulb temperature, wet bulb temperature (or dew point), wind speed, atmospheric pressure)
- Brazie Ranch (solar radiation, dry bulb temperature, wet bulb temperature (or dew point), wind speed, atmospheric pressure)

Geometry

- channel cross sections (estimate, previous field work)
- bed slope (USGS)
- UTM or Lat/Long description of reach (USGS, GIS)

[4] This is now referred to as the Peaking Reach

- locations of inputs (accretions, tributaries, and return flows) and withdrawals (diversions), if any (USGS, GIS)

Initial Conditions

- initial algal biomass if benthic algae is modeled
- model will be used to formulate initial flow and water quality conditions

Boundary Conditions and Validation Data

Calibration and validation of the model will be completed using data from the site at Klamath River above Shovel Creek and an intermediate location between Shovel Creek and the penstock return (to be determined). Boundary conditions and calibration/validation data are summarized in Table 7.

Table 7 JC Boyle Dam penstock return to Copco Reservoir (full flow reach) boundary conditions and calibration/validation data

	Flow/ Stage	Tw	DO	Nutrients[1]	BOD	Algae[2]	Other[3]	Boundary Condition	Cal/Val Site
KR above Penstock Return	H/D	H	H	G	G	G		Yes	No
Penstock Return	H	H	H	G	G	G		Yes	No
Intermediate Location TBD		H	H	G	G	G		No	Yes
KR ab Shovel Ck	H	H	H	G	G	G		Yes[4]	Yes

[1] Nutrients: Org N, NH_4^+, NO_2^-, NO_3^-, Org P, PO_4^{3-} (models may represent different collections of nutrient processes, all models include dominant inorganic forms)

[2] Benthic algae modeling will be completed if required to simulate system response.

[3] Other water quality constituents may be represented as well, e.g., specific conductance.

[4] A flow or stage boundary condition will be required at this location

Sampling Frequency:

H – hourly

D – Daily

M – Monthly

G – Grab sample (frequency varies from sub-daily to monthly)

A.3.6.3 Additional Field Studies

- synoptic water quality study (3 periods – 3 days each):
    - continuously monitoring probes (physical parameters - hourly) at top, middle, and bottom of reach
    - grab samples 2 times per day at top, middle, and bottom of reach to coincide with the continuously monitoring probe deployment locations. Ideally, samples to be collected prior to peaking and after full flows occur.
    - monitor Shovel Creek and any other identified accretions that are deemed significant for temperature (logger) and one grab sample per day

- field reconnaissance to characterize river reach (cross section and slope), identify potential accretions (location and quantity), examine benthic algae conditions, and to locate intermediate sampling point for calibration and validation
- field studies to examine benthic algae conditions for model representation
- additional full meteorological station (Copco Village)

A.3.7 Copco Reservoir

Copco Reservoir is 5.4 miles long with a storage capacity of 46,867 acre-feet[5]. The reservoir has a residence time that ranges from two weeks to a month at typical summer flows and is subject to thermal stratification. Reservoir inflow, other than the Klamath River, is restricted to minor tributaries and spring flows.

A.3.7.1 Modeling Approach

The reservoir will be modeled with WQRRS. (Ultimately, CE-QUAL-W2 was the selected model for this application. This is an update: Change from original framework.)

A.3.7.2 Data Requirements

Meteorological Conditions

- Klamath Falls (solar radiation, dry bulb temperature, wet bulb temperature (or dew point), wind speed, atmospheric pressure)
- Brazie Ranch (solar radiation, dry bulb temperature, wet bulb temperature (or dew point), wind speed, atmospheric pressure)

Geometry

- Bathymetric survey of reach (PacifiCorp)
- UTM or Lat/Long description of reach (USGS)
- locations of inputs (accretions, tributaries, and return flows) and withdrawals (diversions), (USGS)

Initial Conditions

- initial reservoir stage
- initial water quality profile
- initial organic sediment mass
- for river models, initial condition will be developed using the models

Boundary Conditions and Validation Data

For WQRRS calibration and validation will utilize data from the vertical profile site near Copco Dam. The model will be calibrated to effectively simulate outflow conditions as well. Boundary conditions and calibration/validation data are summarized in Table 8.

A.3.7.3 Additional Field Studies

- synoptic water quality study (3 times – one day each): to characterize longitudinal variability in reservoir
    - monitor vertical profiles of temperature, dissolved oxygen, pH, specific conductance, and oxidation-reduction potential (ORP) at a minimum of three points in the reservoir.

[5] Updated Copco Reservoir bathymetric surveys completed in 2001 identified that actual reservoir storage is approximately 40,000 acre-feet.

    - grab samples at above locations. The grab samples should occur at two or three depths in the reservoir, depending on total reservoir depth and thermal profile
    - algal species identification (sample each day at all three sites)
- sediment sampling to determine sediment oxygen demand (SOD) and nutrient release. One set of samples (cores) during the summer season.
- collect samples to identify algal species (monthly at dam site)
- field reconnaissance to quantify potential accretions and depletions to/from reservoir (e.g., springs)
- additional full meteorological station (Copco Village)

Table 8 Copco Reservoir boundary conditions and calibration/validation data

	Flow/ Stage	Tw	DO	Nutrients[1]	BOD	Algae	Other[2]	Boundary Condition	Cal/Val Site
KR ab Shovel Ck	H/D	H/D	H/D	G	G	G	Synoptic	Yes	No
Copco Reservoir Profile	H/D	H/M (P)	M(P)	M (3 Depths)	M (3 Depths)	M (3 Depths)	Sediment Algae species	No	Yes
Copco Release (below Copco)	H/D	H/D	G	G	G	G		Yes[3]	Yes

[1] Nutrients: Org N, NH_4^+, NO_2^-, NO_3^-, Org P, PO_4^{3-} (models may represent different collections of nutrient processes, all models include dominant inorganic forms)

[2] Other water quality constituents may be represented as well, e.g., specific conductance.

[3] A flow or stage boundary condition will be required at this location

Sampling Frequency:

H – hourly

D – Daily

M – Monthly

G – Grab sample (frequency varies from sub-daily to monthly)

A.3.8 Iron Gate Reservoir

Iron Gate Reservoir is 7 miles long with a storage capacity of approximately 58,000 acre-feet. Iron Gate Reservoir acts as a reregulating reservoir for Copco Reservoir hydropower releases. The reservoir has a residence time that ranges from three weeks to over a month at typical summer flows and is subject to thermal stratification. Reservoir inflow, other than the Klamath River, is restricted to minor tributaries and spring flows.

A.3.8.1 Modeling Approach

The reservoir will be modeled with WQRRS. (Ultimately, CE-QUAL-W2 was the selected model for this application. This is an update: Change from original framework.)

A.3.8.2 Data Requirements

Meteorological Conditions

- Klamath Falls (solar radiation, dry bulb temperature, wet bulb temperature (or dew point), wind speed, atmospheric pressure)
- Brazie Ranch (solar radiation, dry bulb temperature, wet bulb temperature (or dew point), wind speed, atmospheric pressure)

Geometry

- Bathymetric survey of reach (PacifiCorp)
- UTM or Lat/Long description of reach (USGS)
- locations of inputs (accretions, tributaries, and return flows) and withdrawals (diversions), (USGS)

Initial Conditions

- initial reservoir stage
- initial water quality profile
- initial organic sediment mass
- for river models, initial condition will be developed using the models

Boundary Conditions and Validation Data

For WQRRS calibration and validation will utilize data from the vertical profile site near Iron Gate Dam. The model will be calibrated to effectively simulate outflow conditions as well. Boundary conditions and calibration/validation data are summarized in Table 9.

Table 9 Iron Gate Reservoir boundary conditions and calibration/validation data

	Flow/ Stage	Tw	DO	Nutrients[1]	BOD	Algae	Other[2]	Boundary Condition	Cal/Val Site
Copco Release (below Copco)	H/D	H/D	G	G	G	G		Yes	Yes
Iron Gate Reservoir Profile	H/D	H/M (P)	M (P)	M (3 Depths)	M (3 Depths)	M (3 Depths)	Sediment Algae	No	Yes
Iron Gate Release to KR (below IG)	H/D	H/D	G	G	G	G		Yes[3]	Yes

[1] Nutrients: Org N, NH_4^+, NO_2^-, NO_3^-, Org P, PO_4^{3-} (models may represent different collections of nutrient processes, all models include dominant inorganic forms)

[2] Other water quality constituents may be represented as well, e.g., specific conductance.

[3] A flow or stage boundary condition will be required at this location

<u>Sampling Frequency:</u>

H – hourly

D – Daily

M – Monthly

G – Grab sample (frequency varies from sub-daily to monthly)

A.3.8.3 Additional Field Studies

- synoptic water quality study (3 times – one day each): to characterize longitudinal variability in reservoir
    - monitor vertical profiles of temperature, dissolved oxygen, pH, specific conductance, and oxidation-reduction potential (ORP) at a minimum of three points in the reservoir.

    - grab samples at above locations. The grab samples should occur at two or three depths in the reservoir depending on total depth and thermal structure
    - algal species identification
- sediment sampling to determine sediment oxygen demand (SOD) and nutrient release. One set of samples (cores) during the summer season.
- collect samples to identify algal species
- more completely represent fish hatchery operations
- additional full meteorological station (Iron Gate Dam or Copco Village)

A.3.9 Klamath River below Iron Gate Dam

The Klamath River below Iron Gate Dam is regulated by upstream reservoir operations. Major tributaries downstream of the dam include the Shasta and Scott River. The reach is moderate to steep and experiences stable flow regime. The transit time between Iron Gate Dam (RM 190) and Seiad Valley (RM 129) during summer flow conditions ranges from one to two days.

A.3.9.1 Modeling Approach

This river reach will be modeled with river models RMA-2 (flow) and RMA-11 (water quality).

A.3.9.2 Data Requirements

Meteorological Conditions

- Brazie Ranch (solar radiation, dry bulb temperature, wet bulb temperature (or dew point), wind speed, atmospheric pressure)

Geometry

- channel cross sections (estimate, previous field work)
- bed slope (USGS)
- UTM or Lat/Long description of reach (USGS, GIS)
- locations of inputs (accretions, tributaries, and return flows) and withdrawals (diversions), if any (USGS, GIS)

Initial Conditions

- initial algal biomass if benthic algae is modeled
- model will be used to formulate initial flow and water quality conditions

Boundary Conditions and Validation Data

Calibration and validation of the model will be completed using data from the site at Klamath River above Shasta River and near Seiad Valley, and possibly an additional intermediate location (to be determined). Boundary conditions and calibration/validation data are summarized in Table 10.

A.3.9.3 Additional Field Studies

- synoptic water quality study (3 periods – 3 days each):): to characterize short-term variability in the reach and for model calibration and validation
    - continuously monitoring probes (physical parameters - hourly) at top and bottom of reach, as well as up to two intermediate locations (above Shasta River and one site to be determined)

  - grab samples one time per day at top, middle, and bottom of reach to coincide with the continuously monitoring probe deployment
  - monitor Shasta River and any other identified tributaries and accretions that are deemed significant for temperature (logger) and one grab sample per day
- field studies to examine benthic algae conditions for model representation
- additional full meteorological station (Iron Gate Dam)

Table 10 Below Iron Gate Dam to Seiad Valley boundary conditions and calibration/validation data

	Flow/ Stage	Tw	DO	Nutrients[1]	BOD	Algae[2]	Other[3]	Boundary Condition	Cal/Val Site
Iron Gate Release to KR (below IG)	H/D	H/D	H	G	G			Yes	No
KR above Shasta River		H	H	G	G			No	Yes
Shasta River inflow	H/D	H/D	H/D	G	G			Yes	No
Scott River inflow	H/D	H/D	H/D	G	G			Yes	No
Seiad Valley	H/D	H	H	G	G			Yes[4]	Yes

[1] Nutrients: Org N, NH_4^+, NO_2^-, NO_3^-, Org P, PO_4^{3-} (models may represent different collections of nutrient processes, all models include dominant inorganic forms)

[2] Benthic algae modeling will be completed if required to simulate system response.

[3] Other water quality constituents may be represented as well, e.g., specific conductance.

[4] A flow or stage boundary condition will be required at this location

Sampling Frequency:

H – hourly

D – Daily

M – Monthly

G – Grab sample (frequency varies from sub-daily to monthly)

B Model Descriptions

B.1 CE-QUAL-W2

CE-QUAL-W2 (v3.1) is a two-dimensional, longitudinal/vertical, hydrodynamic and water quality model. Because the model assumes lateral homogeneity, it is best suited for relatively long and narrow waterbodies exhibiting longitudinal and vertical water quality gradients. The model has been applied to rivers, lakes, reservoirs, and estuaries.

The model predicts water surface elevations, velocities, and temperatures. Temperature is included in the hydrodynamic calculations because of its effect on water density. The water quality algorithms incorporate 21 constituents in addition to temperature including nutrient/phytoplankton/dissolved oxygen (DO) interactions during anoxic conditions. Any combination of constituents can be simulated. Selective relationships pertinent to this application are shown in Figure 1. The effects of salinity or total dissolved solids/salinity on density and thus hydrodynamics are included only if they are simulated in the water quality module. The water quality algorithm is modular, allowing constituents to be easily added as additional subroutines. Selective withdrawal, the representations of internal curtains and weirs, and other features of this model allow the assessment of a wide range of configurations.

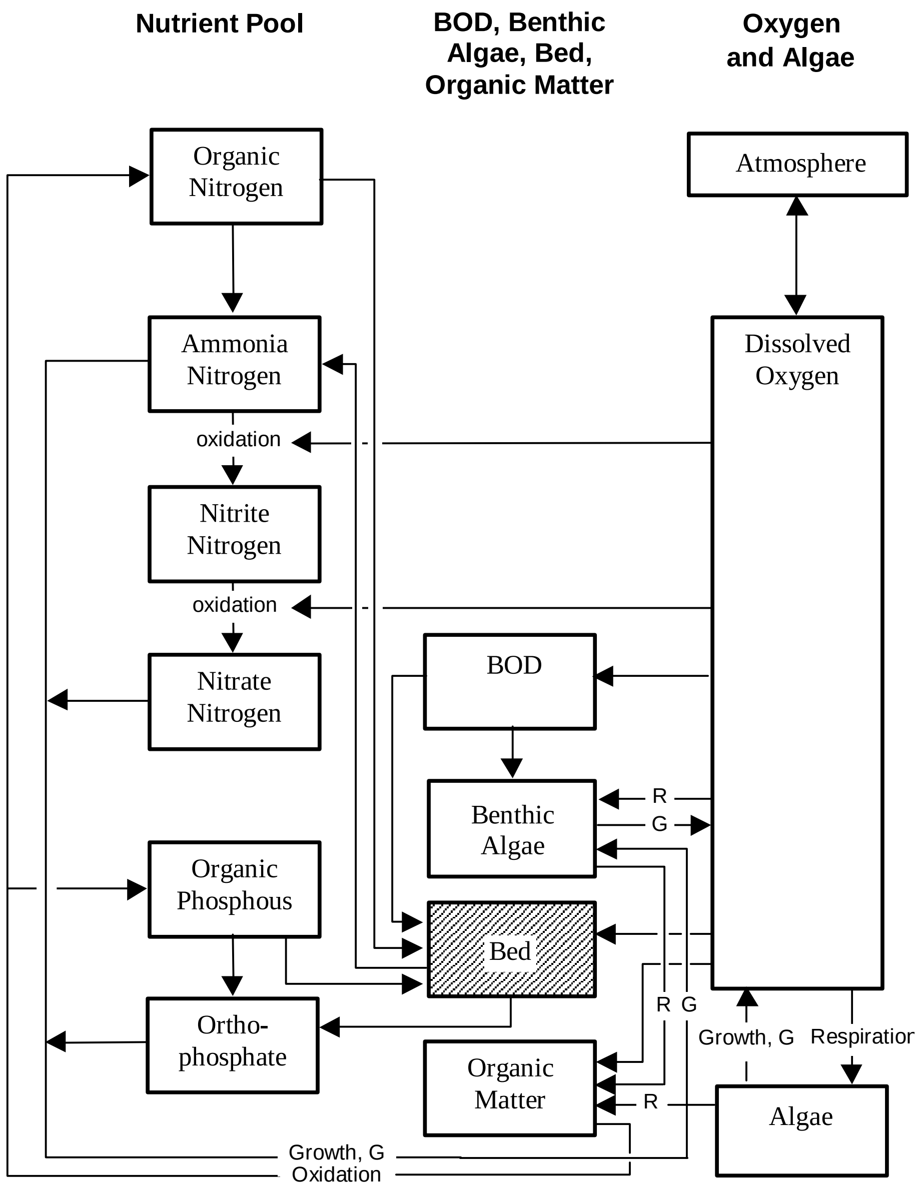


Figure 1. Selected water quality relationships for CE-QUAL-W2

B.2 RMA Models: Hydrodynamics and Water Quality

As with a handful of other numerical models, RMA-2 solves the full flow equations known as the St. Venant Equations, also called the shallow water equations. These equations utilize all terms of the conservation of momentum formulation and provide the most complete description of dynamic flow conditions. Several features of this model that make it a particularly useful tool for the Klamath River include:

- the model is a finite element model and the space-time criteria (e.g., Peclet number) for stability in the numerical solution of the governing equations is a necessary consideration
- the model has an option to represent steep river systems without utilizing unrealistic bed roughness parameters. This steep river system formulation is

critical in representing proper transit times, which is paramount to modeling water quality

- the model has been widely applied (it is one of the most used full hydrodynamic model in the United States) to a variety of river and estuary systems in the United States as well as internationally. The model author is available for support.

RMA-11 solves the advection-diffusion equation to determine the fate and transport of up to 16 constituents. Selected process pertinent to this application are illustrated in Figure 2. The water quality algorithm is modular allowing constituents to be added. Other features include:

- the model interfaces directly with the geometry and output of RMA-2
- all standard water quality routines are from QUAL2E. These routines have been tested and reviewed for completeness and correctness
- Additional processes have been added to the model to simulate attached algae

The RMA-2 and RMA-11 Combination

Fundamental to effectively modeling water quality is the proper representation of the flow regime (hydrodynamics). The two models RMA-2 and RMA-11 provide a complete hydrodynamic model with a comprehensive water quality model, creating a powerful tool for assessing flow and water quality response in complex river systems. Although this model resides in the private sector, the source code is supplied with the executable when purchased. That is, these are open codes (as opposed to many proprietary codes where the source code is unavailable to the user). Further, many of the model applications have occurred in the public sector (government agencies, universities, etc.) and the RMA-2 code has undergone intensive peer review.

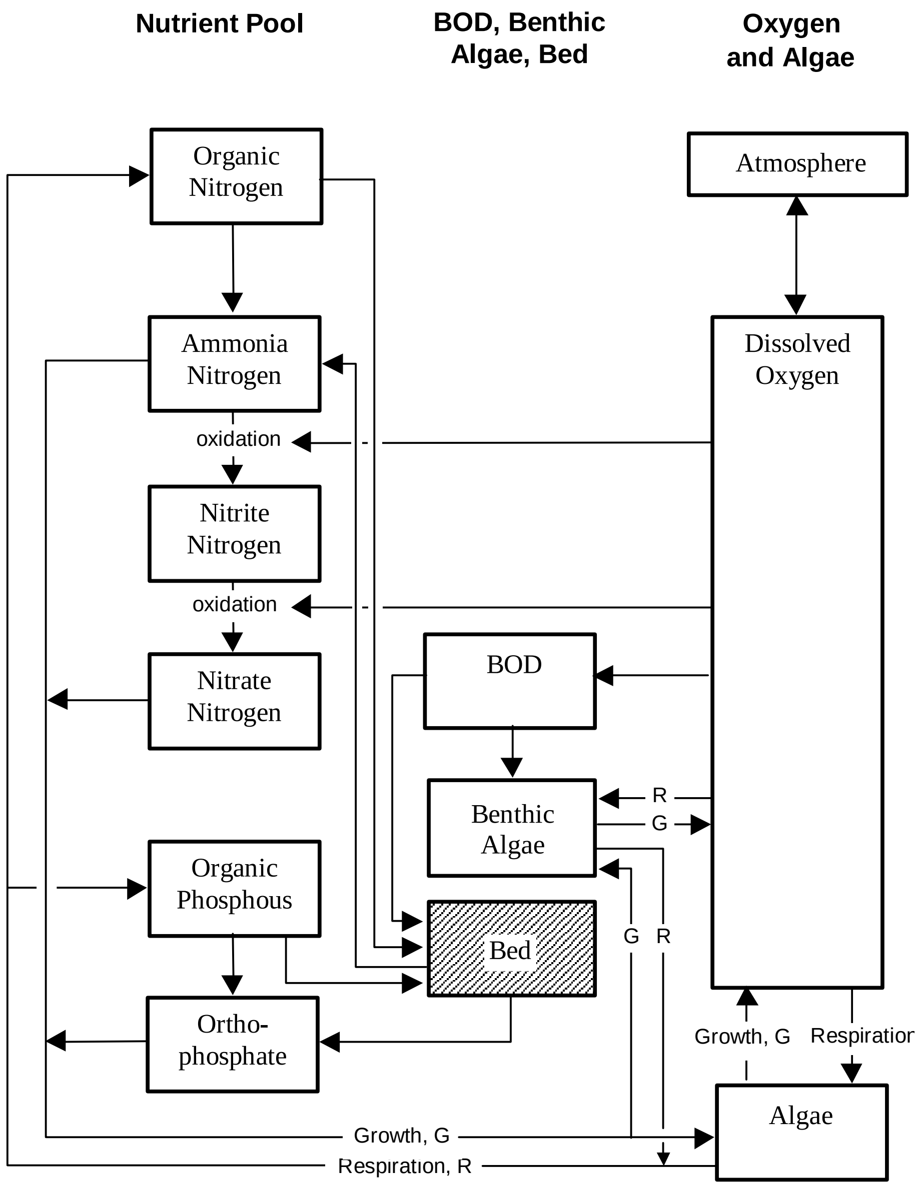


Figure 2. Selected water quality relationships for RMA-11

B.3 WQRRS (Reservoir Module)[6]

The model WQRRS is an Army Corps of Engineers river and reservoir system model, but the river and reservoir modules can be modeled separately. For this application the reservoir module is applied. Some of the attributes that are unique to WQRRS include the fact that is essentially an ecological model, representing not only water quality but also trophic levels from primary production, zooplankton predation, up to fish. Although all these processes are not deemed necessary for this application, because of its more comprehensive treatment of primary production it allows more flexibility, (e.g., benthic

[6] The WQRRS model was replaced with CE-QUAL-W2 at JC Boyle, Iron Gate, and Copco Reservoirs.

algae and phytoplankton, two species of phytoplankton, grazing by zooplankton). Further, the model readily allows for the simulation of selective withdrawal. The model has a few modifications/updates that may be pertinent to the Klamath River mainstem reservoirs, including

1) sediment nutrient release dynamics for ammonia and phosphorous
2) the ability of the analyst to examine the impacts of hypolimnetic oxygenation
3) seasonal evaporation coefficients

B.4 Interfacing the Models

Modeling the Klamath River reaches and reservoirs would require use of different models for reservoir and river reaches. The process of interfacing or linking the models is a matter of writing separate computer programs to process the output from one model (e.g., river model) such that it forms the input to the subsequent model (e.g., reservoir model). A necessary, but straightforward task. The end result is a model framework that can be used to examine individual reaches, or larger sections of the river and reservoir system.

B.5 Model Contact Information

B.5.1 CEQUAL-W2

U.S. Army Corps of Engineers, Waterways Experiment Station
Environmental Laboratory
U.S. Army Engineer Waterways Experiment Station
3909 Halls Ferry Road
Vicksburg, MS 39180
Contact: Thomas M. Cole(tcole@lasher.wes.army.mil)

B.5.2 RMA-2/RMA-11

Resource Management Associates PTY LTD
9 Dumaresq Street
Gordon
NSW 2071
Contact: Dr. Ian King (I.King@UNSW.EDU.AU)

B.5.3 WQRRS: Water Quality for River-Reservoir Systems

US Army Corps of Engineers – Hydrologic Engineering Center
609 2nd Street
Davis, CA 95616
Contact: none

C River Geometry

C.1 River Location Description

The x-y coordinates describing the river location were defined using a digitized version of the 1:24,000 USGS topographic quadrangles provided by CH2M Hill. The coordinates provided were Eastings and Northings in the UTM Zone 10 NAD 83 projection (meters) rather than in degrees/minutes/seconds. The USGS hydro coverage did not cover the reservoirs in the upper basin, these were digitized by CH2M Hill. A centerline was used to depict the line of the river through the reservoirs. The dataset provided by CH2M Hill had and a length of 257.08 river miles (from Link Dam to the mouth) and coordinates that were irregularly spaced. This data set was processed using a program called “Make River” that uses linear interpolation to produce an evenly spaced set of coordinates, and consequently shortens the river slightly. The coordinates were processed to 150-meter intervals, with a new river length 253.88 miles. This corresponded more closely with the most commonly used river mile index developed by the USGS. Once completed, this geometry was used to define the individual reaches as well as the description of the “without project” scenario.

D Flow Data

D.1 Tributaries from Iron Gate Dam to Turwar

Accretions from Iron Gate Dam to Turwar were defined and quantified according to the methodology identified by USGS (1995, 1997). In sum, the river was divided into multiple segments (reaches) based on available gages with full coverage between 1961 and 1922. USGS used monthly averages to determine accretions and depletions for each reach based on the differences in gage readings. These accretions and depletions were then assigned to individual tributaries based on estimated basin area (individual sub-basin contributions were obtained from personal communication with Mr. M. Flug). Not all tributaries to the Klamath River were included.

For this exercise, 7-day average values were used to identify accretions and depletions for identified tributaries. The same tributaries identified by USGS (1997) were used herein. The methodology is outlined below.

Total Accretion from Iron Gate Dam to Seiad Valley. Accretion value is equal to the flow at gage 11520500 (Klamath River nr. Seiad Valley) minus the sum of the flows at gages 11516530 (KR below Iron Gate Dam), 11517500 (Shasta River nr. Yreka), 11519500 (Scott River nr Fort Jones). This reach accretion is further sub-divided into shorter sub-reaches by according to the following criteria.

Klamath River from Iron Gate Dam to the confluence of the Shasta River.
Accretion equals 24.2% of the total area accretion.

This accretion is distributed between the following creeks as determined by watershed area:

- Bogus Creek – 41%
- Willow Creek – 22%
- Cottonwood Creek – 37%

Klamath River from the confluence of the Shasta River to the confluence of the Scott River.
Accretion equals 38.2% of the total area accretion.

This accretion is distributed between the following creeks as determined by watershed area:

- Humbug Creek – 28%
- Beaver Creek – 32%
- Horse Creek – 40%

Scott River from Ft. Jones to the confluence of the Klamath River.
Accretion equals 29.0% of the total area accretion.

Klamath River from the confluence of the Scott River to Seiad valley.
Accretion equals 8.6% of the total area accretion. This accretion is applied at Grider Creek.

Total Accretion from Klamath River from Seiad Valley to Orleans. Accretion equals the flow at gage 11523000 (Klamath River at Orleans) minus the sum of the flows at gages 11520500 (Klamath River nr Seiad Valley), 11522500 (Salmon River at Somes Bar, Ca), and 11521500 (Indian Cr nr Happy Camp).

This accretion is distributed between the following creeks as determined by watershed area:

Thompson Creek – 16.6%
Elk Creek – 16.6%
Clear Creek – 21.4%
Ukonom Creek – 12.9%
Dillon Creek – 32.5%

Total Accretion from Klamath River from Orleans to the Mouth. Accretion equals gage 15530500 (KR nr Klamath (Turwar), CA) minus gage 15523000 (KR at Orleans) and 11530000 (Trinity River at Hoopa).

Klamath River from Orleans to the confluence of the Trinity River. Accretion equals 29.3% of the total area accretion.

This accretion is distributed between the following creeks as determined by watershed area:

Camp Creek – 33.3%
Red Cap Creek – 33.3%
Bluff Creek – 33.3%

Trinity River from Hoopa to the confluence with the Klamath River. Accretion equals 12.3% of the total area accretion.

Klamath River from the confluence of the Trinity River to the mouth. Accretion equals 58.4% of total area accretion.

This accretion is distributed between the following creeks as determined by watershed area:

Pine Creek – 33.3%
Tectah Creek – 33.3%
Blue Creek – 33.3%

E Meteorological Data

The required hourly information for the meteorological input file consists of: air temperature (^oC), dew point temperature (^oC), wind speed (m/s), wind direction (radians), cloud cover (scale 0-10) and solar radiation (W/m^2). The Agrimet station located in Klamath Falls, Oregon, (KFLO) provided all of these parameters except for cloud cover. Wind speed and wind direction had to be converted to the units consistent with model requirements. The station provided hourly cumulative solar radiation. The difference between the cumulative solar radiation at each hour was determined and converted to the necessary units. Cloud cover was calculated from the daily summation of solar radiation provided by the station, using the ideal sine wave representation of the maximum possible solar radiation throughout the year to determine the ratio of measured radiation to total radiation. This ratio was then converted to the appropriate scale for input into the model. It should be noted that this scale, from 0-10 is different from the scale required for RMA modeling, which is a scale from 0-1. Both sets of cloud cover were calculated from the same solar radiation data. Atmospheric pressure was unavailable, and was calculated based on elevation and a constant sea level pressure of 1013 mb.

Klamath Falls data was used throughout the modeling domain, i.e., from Link Dam (RM 255) to the mouth (RM 0) because it was the most complete and consistently avaiable record. However, it is clear that atmospheric conditions vary appreciably throughout the study reach due to elevation, orographic features, proximity to the Pacific Ocean, and the shear size of the study area. Meteorological observations within the basin are limited and non-uniformly distributed. Further, available parameters vary among stations. To overcome some of the challenges with representing meteorological conditions system-wide, PacifiCorp installed two additional weather stations (at Iron Gate Dam and Copco Village) to gather additional information within the project area. These stations, coupled with the station at Klamath Falls, the station maintained by the Yurok Tribe at Weitchpec, and observation locations in the Shasta Valley (National Weather Service at Montague and California Department of Forestry at Brazie Ranch) were examined to determine meteorological variability throughout the basin and, to the extent feasible, adjust parameters to more fully represent local conditions.

Klamath Falls (KFLO) meteorological data was used directly for the following reaches

- Link River
- Lake Ewauna to Keno Dam
- Klamath River from Keno Dam to JC Boyel Reservoir
- JC Boyle Reservoir
- JC Boyle Dam to Copco Reservoir

The only variations herein included modifying atmospheric pressure for elevation. Adjustment to meteorological parameters for Copco and Iron Gate Reservoirs, as well as the Klamath River reach from Iron Gate Dam to the mouth are presented below.

E.1 Copco and Iron Gate Reservoirs

Because Copco and Iron Gate Reservoir are roughly 1500 feet and 1700 feet, respectively, lower than Klamath Falls, the air temperature was adjusted to accommodate for the change in elevation. A lapse rate of 3.0 °C, based on data from Klamath Falls and a meteorological station at Iron Gate Dam. Air temperature was adjusted according to the following formula, based on Linacre (1992).

$$T_1 = T_2 + 0.003h \qquad (1)$$

Where:
- $T1$ = temperature at site 1
- $T2$ = temperature at site 2
- h = $E_2 - E_1$, meters
  - E_1 = Elevation of site 1
  - E_2 = Elevation of site 2

For the purposes of this study an average elevation of Copco and Iron Gate Reservoirs was applied (2450 ft (746.77 m)). Field data did not suggest any additional relationships between the Klamath Falls and Iron Gate Reservoir site. Thus, the remaining meteorological parameters from the KFLO station were not modified.

E.2 Meteorological Conditions below Iron Gate Dam

A review of available meteorological data at multiple locations in the Klamath River basin suggests variable meteorological conditions throughout the study area. Meteorological data are available in various forms, formats, frequencies, and for selected parameters at the several meteorological stations in the basin. Six stations were identified for meteorological data comparison and assessment for the 2002 field season (Table 1).

Table 11 Inventory of full meteorological stations located within the project area.

Station Name	Agency	Installation Date	Parameters	Elevation (ft)	Lat/Long
Klamath Falls	U.S. Bureau of Reclamation	3/31/99-present	S,W,Ta,P, RH,DP	4100	42°01’ 53”N 121°45’ 18”W
Copco Reservoir	PacifiCorp	6/7/02-present	S,W,Ta,P, RH,DP	2625 (approx)	n/a
Iron Gate Reservoir	PacifiCorp	6/7/02-present	S,W,Ta,P, RH,DP	2350 (approx)	n/a
Brazie Ranch	California Dept. of Forestry	1995/2000-present	S,W,Ta,RH	3020	41.6870N 122.6000W
Montague	National Weather Service	1930-present*	W,Ta,RH, DP,P	2518.4	41°44'N 122°33'W
Weitchpec	Yurok Tribe	2/11/02-present	S,W,Ta,RH,DP, P	300 (approx)	

* Data not archived until 2001. Sub-daily data not available prior to April 2001.
S – Solar Radiation; P – Atmospheric pressure
W – Wind Speed; RH – Relative humidity
Ta – Air temperature; DP – Dew point temperature

As illustrated in Table 1, meteorological monitoring is not consistent and the records are not particularly long. To include as many years as possible for analysis, Klamath Falls (KFLO) was used as the base data set, providing 3 full years of meteorological data. This data set was then compared with available records for 2002 to determine if there were clear relationships between Klamath Falls and the middle and lower Klamath basin regions. Common parameters used for comparison included air temperature (dry bulb), dew point temperature, and wind speed.

E.2.1 Air Temperature

Monthly mean air temperature was compared at each site from May through December (Figure 1). Lapse rates from Linacre (1992) were on the order of 6°C per 1000 meters of elevation change. Based on the available data, this rate of change appeared excessive. A lapse rate of 3°C per 1000 meters of elevation change was selected as a maximum.

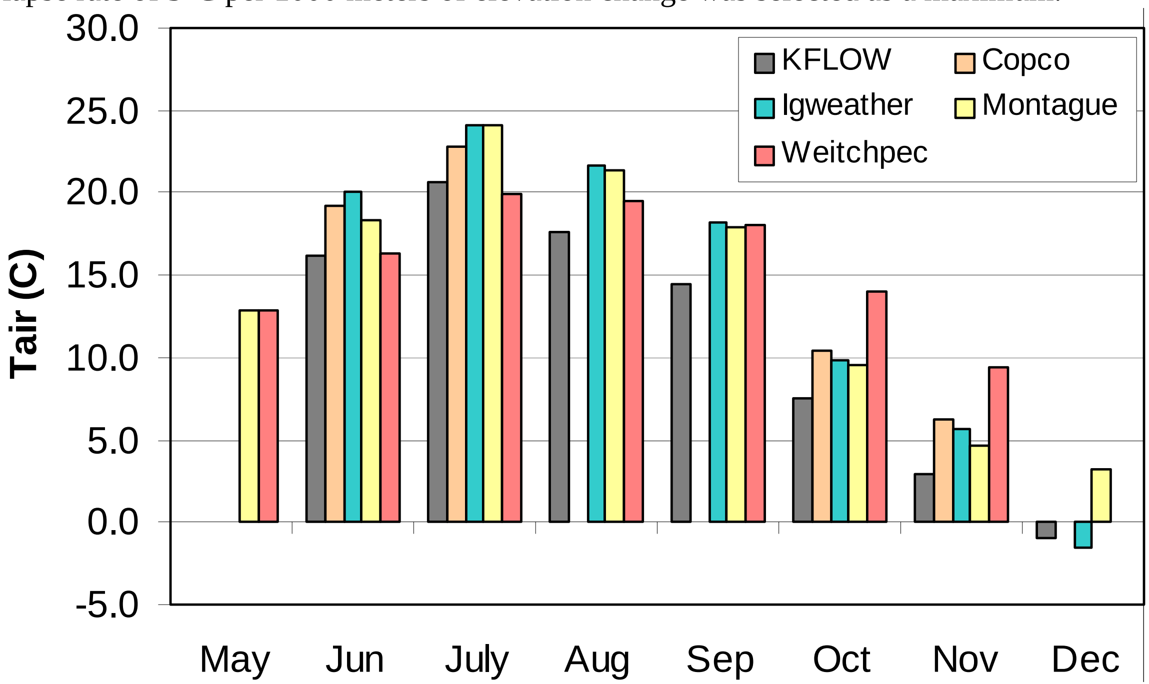


Figure 1 Air temperature at five locations in the Klamath Basin

The lapse rate for air temperature varied seasonally. The higher elevations around Klamath Falls (elevation >4000 ft) experience cold winters and relatively mild summer air temperatures. The coastal area experiences cool winters, with few days below freezing, and mild summers, similar to those found around Klamath Falls, followed by warm fall conditions. Finally the middle Klamath Basin experiences cold winters, hot summer, and warm fall conditions. The corrections based on the identified lapse rates are shown in Table 2.

Table 12 Air temperature corrections, based on month for Klamath River temperature modeling

Month	Correction: Klamath Falls (°C)	Correction: Iron Gate to Orleans (°C)	Correction: Orleans to Turwar (°C)
January	0.0	0.0	3.5
February	0.0	0.0	3.5
March	0.0	0.0	2.5
April	0.0	2.5	1.5
May	0.0	2.5	0.5
June	0.0	2.5	0.0
July	0.0	2.5	0.0
August	0.0	2.5	0.5
September	0.0	2.5	1.5
October	0.0	2.5	2.5
November	0.0	2.5	3.5
December	0.0	0.0	3.5

Positive corrections are added to the KFLO data to arrive at local conditions

E.2.2 Dew Point

Monthly mean dew point temperature was compared at each site from May through December (Figure 2). Although most locations were quite similar, Weitchpec showed a marked deviation.

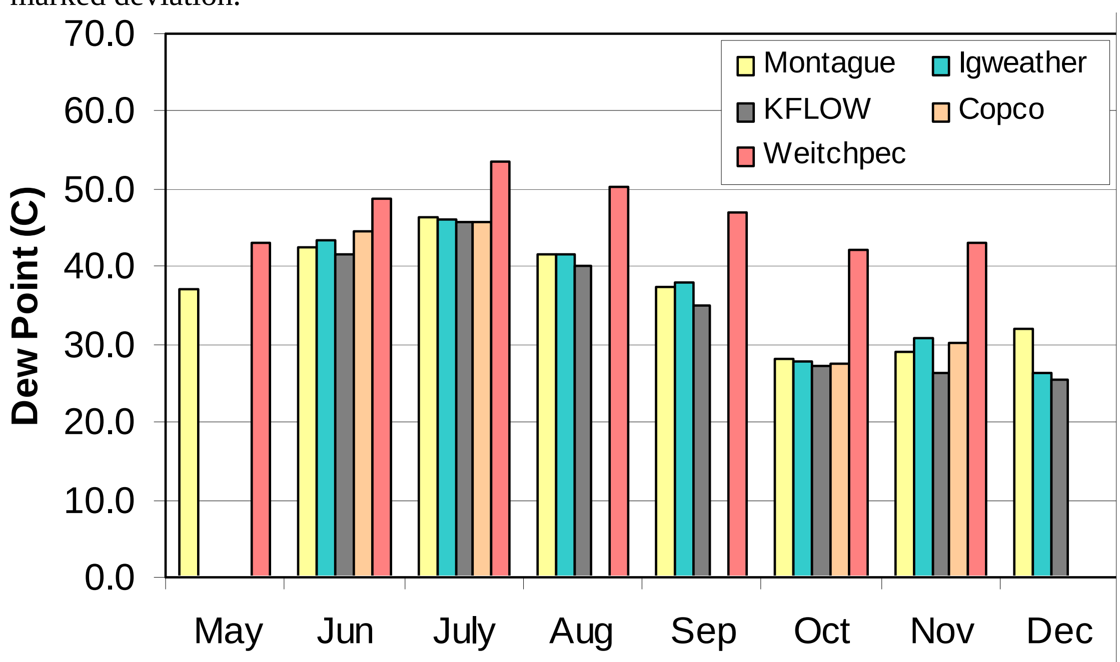


Figure 2 Dew point temperature at five locations in the Klamath Basin

A lapse rate of 6.9°C per 1000 meters of elevation change was selected as a maximum for dew point temperature. This lapse rate was only applied to the lower river region –

below Orleans. Further the correction was applied seasonally as shown in Table 3. Dew Point temperatures were used to determine wet bulb temperatures for use in the model.

Table 13 Dew point temperature corrections, based on month for Klamath River temperature modeling

Month	Correction: Klamath Falls (°C)	Correction: Copco and Iron Gate Res. (°C)	Correction: Iron Gate to Orleans (°C)	Correction: Orleans to Turwar (°C)
January	0.0	0.0	0.0	8.0
February	0.0	0.0	0.0	8.0
March	0.0	0.0	0.0	8.0
April	0.0	0.0	0.0	8.0
May	0.0	0.0	0.0	5.5
June	0.0	0.0	0.0	4.0
July	0.0	0.0	0.0	4.0
August	0.0	0.0	0.0	5.5
September	0.0	0.0	0.0	5.5
October	0.0	0.0	0.0	8.0
November	0.0	0.0	0.0	8.0
December	0.0	0.0	0.0	8.0
Positive corrections are added to the KFLO data to arrive at local conditions				

E.2.3 Wind Speed

Monthly mean wind speed was compared at each site from May through December (Figure 3).

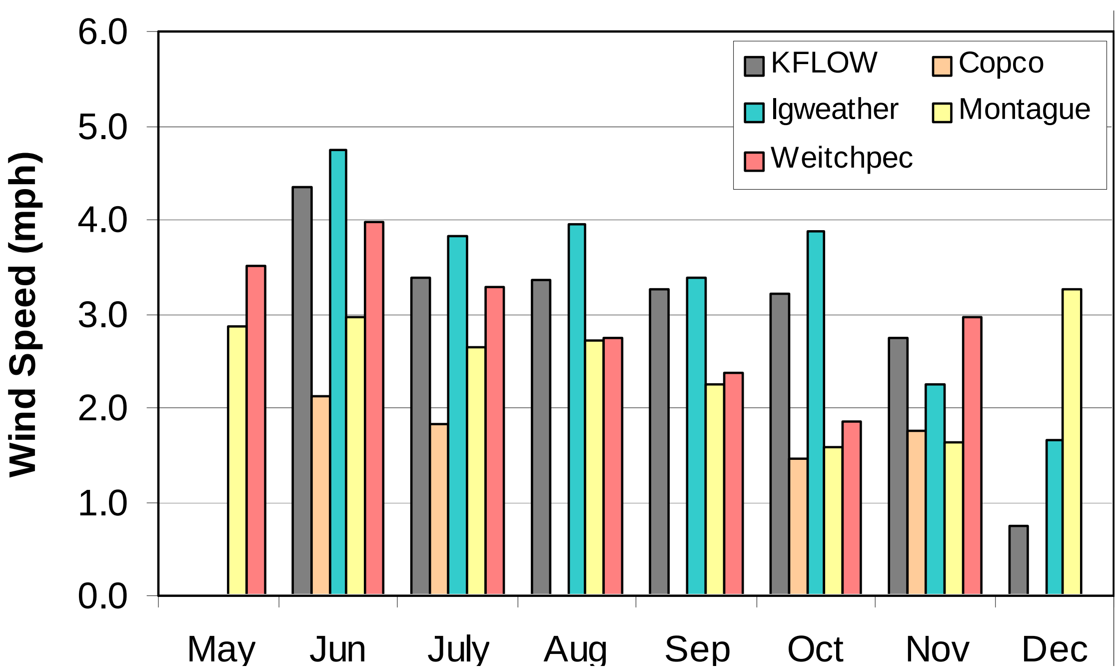


Figure 3 Wind speed at five locations in the Klamath Basin

Although seasonal variations are apparent in the mean monthly data, there was no clear trend (with the exception of Copco Reservoir, which due to a short record was not adjusted) or methods to make adjustments to wind. All sites utilized the KFLO wind data.

E.2.4 Atmospheric Pressure

Atmospheric pressure was corrected for elevation or calculated based on elevation.

E.2.5 Solar Radiation

Solar Radiation from Klamath Falls was used at all locations.

E.2.6 Summary

Based on air temperature the basin was divided into three meteorological "regions" (Figure 4). The upper basin extends from Link Dam to Copco Reservoir and utilizes Klamath Falls meteorological data. The middle region extends from Iron Gate Dam to Orleans The lower region, from Orleans to Turwar. Each reach is summarized below, data are summarized in Table 4.

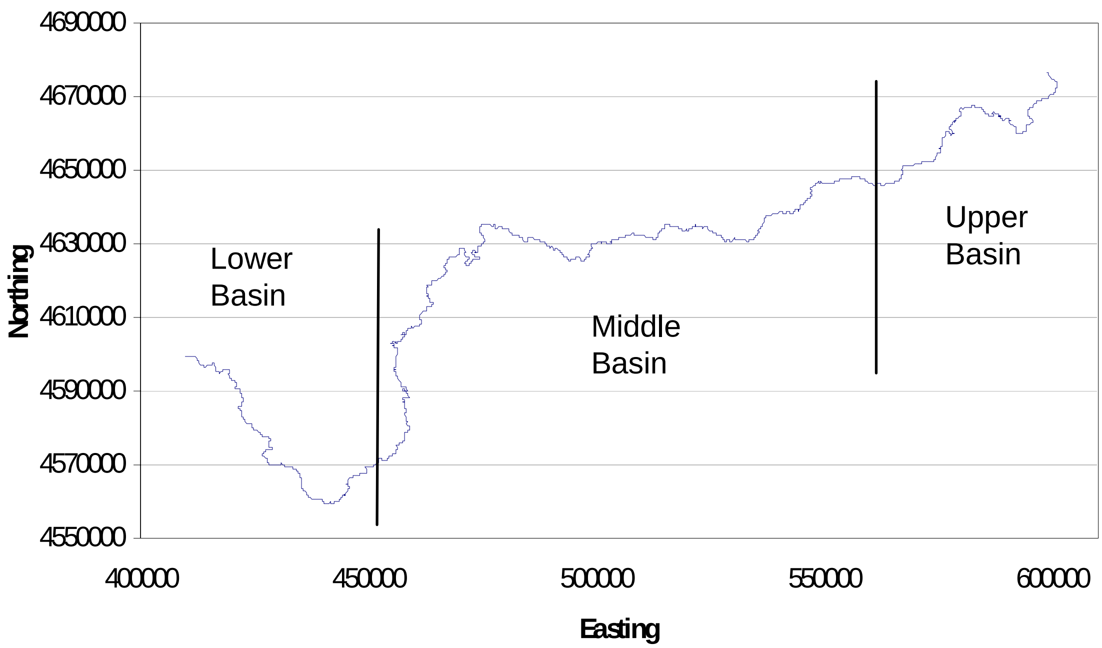


Figure 4 Meterological regions in the study area.

<u>Iron Gate Dam to Orleans</u>

The Klamath River from Iron Gate Dam to Orleans was modeled with RMA-11 for water temperature. The meteorological data set used for these models was based on KFLO data with the air temperature and atmospheric pressure corrected for elevation difference based on an elevation of 1320 at Seiad Valley. No modification was made to dew point temperatures, wind speed, or solar radiation. Dew point was converted to wet bulb temperatures for use in RMA-11.

Orleans to Turwar

The Klamath River from Orleans to Turwar was modeled with RMA-11 for water temperature. The meteorological data set used for these models was based on KFLO data with the air temperature, dew point, and atmospheric pressure corrected for elevation difference based on an elevation of 300 ft near the Trinity River. No modification was made to wind speed, or solar radiation. Dew point was converted to wet bulb temperatures for use in RMA-11.

Table 14 Meteorological Data used in model simulations

Location	Representative Elevation	Solar	Tair	Dew Point	Wind Speed	Barometric Pressure
Upper Basin	Klamath Falls	KFLO	KFLO	KFLO	KFLO	f(elevation)
Middle Basin*	Seiad Valley and Copco/Iron Gate*	KFLO	KFLO Corrected[1]	KFLO	KFLO	f(elevation)
Lower Basin	Weitchpec	KFLO	KFLO Corrected[2]	KFLO Corrected[3]	KFLO	f(elevation)

[1] Lapse Rate of 3.0°C per 1000 m of elevation change: April 1-Dec. 1

[2] Lapse Rate of 3.0°C per 1000 m of elevation change: seasonally

[3] Lapse Rate of 6.9°C per 1000 m of elevation change: seasonally

* For Existing Condition and Steady Flow scenarios, CE-QUAL-W2 representations of Copco and Iron Gate Reservoir use lapse rates and atmospheric pressure calculated on the average elevation of these two reservoirs. For the Without Project Scenario, KFLO data is used, without modification, from Link Dam to Iron Gate Dam. For all simulations between Iron Gate Dam and Orleans, Seiad Valley is used as the elevation for lapse rate and atmospheric pressure calculations.

F Water Quality Data

The 2002 field work was divided into two types of sample collection: monthly sampling and synoptic surveys. E&S Environmental performed the monthly sampling and both E&S and Watercourse Engineering, Inc. performed the synoptic surveys. There were nine monthly sampling sessions and three synoptic surveys performed during the 2002 collection. Field personnel collected four hundred twenty one sets of water samples from twenty two sites along the Klamath River from March 26 through November 13, 2002. The water sample sets were sent to Basic Laboratory in Redding, CA to be analyzed for total alkalinity, total Kjedhal nitrogen, ammonia, nitrate/nitrite, total phosphorus, ortho-phosphate, and biological oxygen demand. These parameters will be used to characterize the water quality in the main stem of the Klamath River, to identify water quality parameters of concern within selected river reaches, and to estimate input parameters for water quality models. Watercourse Engineering, Inc, in Napa, CA is responsible for ensuring the reliability of the data. In order to ensure data reliability, field personnel incorporated external quality assurance samples (QA samples) with the production samples as per the Quality Assurance Project Plan (QAPP) adopted by PacifiCorp and the U.S. Bureau of Reclamation (USBR).

The 2002 field data are attached in the following table.

Date Sampled	Time	Depth, m	Site Name	Total Alk mg/L	Total Kjeldahl Nitrogen mg/L	Ammonia as N mg/L	Nitrate+Nitrite as N mg/L	Total Phos-phorous as P mg/L	Ortho Phosphate as P mg/L	Bio-chemical Oxygen Demand mg/L	Tw C	DO mg/L	EC µS/cm	pH
3/26/2002	1012		Klamath R below JC Boyle Dam	65	0.9	0.14	0.27	0.51	0.11	<3	7.52	11.54	128	8.02
3/26/2002	1057		Klamath R Bypass Reach above Powerhouse	68	0.2	0.09	0.23	0.33	0.12	<3	9.29	11.89	108	8.21
3/26/2002	1113		JC Boyle Powerhouse Release	65	1.0	0.11	0.24	0.31	0.10	3	7.79	11.75	128	7.89
3/26/2002	1206		Spencer Creek	38	1.0	0.07	<0.05	0.15	0.05	<3	4.21	11.26	42	7.80
3/26/2002	1237		Klamath R above JC Boyle Reservoir	65	1.0	0.13	0.18	0.48	0.12	<3	8.86	10.32	126	7.92
3/26/2002	1355	1	JC Boyle Reservoir at Dam	61	1.0	0.11	0.21	0.30	0.10	<3	8.21	10.16	127	7.80
3/26/2002	1407	8	JC Boyle Reservoir at Dam	60	1.2	0.12	0.20	0.37	0.11	3	7.20	9.83	129	7.75
3/26/2002	1443		JC Boyle Reservoir upper	62	1.2	0.09	0.25	0.37	0.10	4	9.11	10.54	127	7.84
3/26/2002	1543		Klamath R below Keno Dam	64	1.0	0.12	0.12	0.50	0.10	3	8.19	10.85	126	7.90
3/27/2002	1051		Klamath R above Shovel Creek	64	0.8	<0.05	0.32	0.67	0.17	<3	7.78	11.36	119	8.04
3/27/2002	1103		Shovel Creek	43	<0.2	<0.05	<0.05	0.46	0.27	<3	5.93	11.25	60	8.05
3/27/2002	1213	1	Copco Reservoir at Dam	69	0.7	<0.05	0.23	0.70	0.24	<3	8.98	11.82	127	8.08
3/27/2002	1233	18	Copco Reservoir at Dam		0.8	0.06	0.31	0.70	0.13		6.16	9.81	121	7.77
3/27/2002	1237	25	Copco Reservoir at Dam	69	0.9	0.11	0.31	0.30	0.40	<3	6.03	9.57	120	7.68
3/27/2002	1321		Fall Creek	74	<0.2	0.05	0.07	0.25	0.25	<3	9.93	10.73	96	8.25
3/27/2002	1358		Klamath R above Irongate Reservoir	69	0.6	0.06	0.26	0.41	0.37	3	7.97	10.69	123	7.89
3/27/2002	1415		Jenny Creek	47	0.2	<0.05	<0.05	0.30	0.24	<3	7.67	12.59	62	7.99
3/27/2002	1452	1	Irongate Reservoir above Dam	70	0.8	<0.05	0.23	0.39	0.32	<3	8.97	13.58	123	8.17
3/27/2002	1509	14	Irongate Reservoir above Dam	70	0.8	0.08	0.39	0.50	0.38	<3	6.80	11.04	120	7.76
3/27/2002	1516	30	Irongate Reservoir above Dam	71	0.6	0.11	0.43	0.45	0.34	<3	6.45	10.82	118	7.70
3/27/2002	1607		Klamath R below Irongate Dam	70	0.7	0.07	0.23	0.38	0.36	3	8.65	12.37	123	8.10
3/27/2002	1654		Shasta R	161	0.4	0.06	<0.05	0.87	0.68	7	14.44		409	8.87
4/16/2002	915		Klamath R below JC Boyle Dam	54	0.9	0.11	0.13	0.18	0.16	<3	12.04	9.85	108	7.91
4/16/2002	1104		Klamath R Bypass Reach above Powerhouse	61	0.2	<0.05	0.15	0.53	0.20	<3	10.60	10.67	99	8.33
4/16/2002	1113		JC Boyle Powerhouse Release	53	0.8	0.14	0.14	0.24	0.17	<3	12.22	9.35	108	7.85
4/16/2002	1140		Spencer Creek	23	<0.2	<0.05	<0.05	0.20	0.09	<3	4.71	11.35	28	7.89
4/16/2002	1220		Klamath R below Keno Dam	72	1.0	0.14	0.13	0.42	<0.03	4	11.94	9.74	175	7.75
4/16/2002	1255		Klamath R above JC Boyle Reservoir	69	0.9	0.07	0.31	0.36	0.19	<3	12.17	10.10	177	8.06
4/16/2002	1443	1	JC Boyle Reservoir at Dam	54	0.7	0.10	0.13	0.27	0.16	<3	12.28	8.58	108	7.90
4/16/2002	1452	8	JC Boyle Reservoir upper	57	0.9	0.12	0.18	0.41	0.20	<3	11.88	8.62	112	7.79

Date Sampled	Time	Depth, m	Site Name	Total Alk mg/L	Total Kjeldahl Nitrogen mg/L	Ammonia as N mg/L	Nitrate+Nitrite as N mg/L	Total Phos-phorous as P mg/L	Ortho Phosphate as P mg/L	Bio-chemical Oxygen Demand mg/L	Tw C	DO mg/L	EC µS/cm	pH
4/16/2002	1528		JC Boyle Reservoir at Dam	66	0.8	<0.05	0.26	0.32	0.19	<3	11.21	9.55	160	7.86
4/16/2002	1604		Klamath R above Shovel Creek	60	0.8	0.06	0.25	0.41	0.20	<3	11.35	10.40	133	8.10
4/16/2002	1609		Shovel Creek	32	0.2	0.06	<0.05	0.25	0.17	<3	4.75	11.89	38	8.08
4/16/2002	1815		Shasta R	264	0.5	0.06	<0.05	0.41	0.32	4	11.52	10.85	382	8.79
4/17/2002	1045	1	Copco Reservoir at Dam	65	0.7	0.07	0.20	0.31	0.17	<3	13.15	9.14	137	8.15
4/17/2002	1104	15	Copco Reservoir at Dam	64	0.8	0.16	0.23	0.35	0.15	<3	9.33	7.60	124	7.74
4/17/2002	1110	25	Copco Reservoir at Dam	69	1.0	0.27	0.28	0.49	0.24	<3	7.12	5.93	124	7.48
4/17/2002	1200		Klamath R above Irongate Reservoir	65	0.8	<0.05	0.21	0.27	0.15	<3	12.33	9.45	132	7.82
4/17/2002	1210		Fall Creek	72	<0.2	<0.05	0.05	0.21	0.11	<3	8.75	11.34	95	8.15
4/17/2002	1230		Jenny Creek	44	<0.2	<0.05	<0.05	0.22	0.09	<3	5.35	12.24	56	8.10
4/17/2002	1342	1	Irongate Reservoir above Dam	60	0.7	0.07	0.13	0.39	0.09	<3	12.57	9.97	122	8.02
4/17/2002	1358	12	Irongate Reservoir above Dam	62	0.6	0.09	0.20	0.19	0.12	<3	9.85	8.64	119	7.79
4/17/2002	1412	30	Irongate Reservoir above Dam	66	0.7	<0.05	0.60	0.36	0.15	<3	6.45	7.60	118	7.52
4/17/2002	1515		Klamath R below Irongate Dam	60	0.5	0.05	0.14	0.20	0.12	<3	12.48	9.95	124	7.86
5/20/2002	1500		Klamath R above Copco		0.8	0.05	0.18	0.21	0.14		14.23b	9.8b	230b	8.81b
5/20/2002	1600		Klamath River at State Line		1.1	0.05	0.11	0.26	0.15		14.25b	8.91b	254b	8.4b
5/21/2002	900		Klamath R above Copco		0.6	0.08	0.12	0.16	0.17		12.23	9.34	254	8.17
5/21/2002	1000		Klamath River at State Line		0.6	0.09	0.17	0.53	0.18		12.44	9.45	250	8.31
5/21/2002	1028		Klamath Lake above Link Dam		0.8	0.21	<0.05	0.49	0.13		12.20	9.20	137	8.20
5/21/2002	1045		Mouth of Link R		0.8	0.29	<0.05	0.41	0.12		12.50	9.70	105	8.20
5/21/2002	1125		Shovel Creek		<0.2	0.07	<0.05	0.65	0.15					
5/21/2002	1141		Klamath R below Keno Dam		0.9	0.17	<0.05	0.63	0.14		13.00	9.40	166	8.60
5/21/2002	1209		Klamath R above JC Boyle Reservoir		<0.2	0.16	0.10	0.43	0.16		13.60	9.30	155	8.50
5/21/2002	1234		Spencer Creek		<0.2	0.10	<0.05	0.21	0.09		9.20	10.20	71	8.60
5/21/2002	1303		Klamath R Bypass Reach above Powerhouse		0.3	0.13	0.13	0.33	0.21		12.20	10.00	151	8.70
5/21/2002	1306		JC Boyle Powerhouse Release		0.9	0.24	0.10	0.45	0.17		13.90	8.80	190	8.40
5/21/2002	1330		Klamath River at State Line		0.7	0.29	0.15	0.30	0.18		13.51	9.17	246	8.54
5/21/2002	1350		Klamath R below JC Boyle Dam		0.8	0.18	0.12	0.43	0.16		13.80	9.00	209	8.40
5/21/2002	1415		Klamath R above Copco		0.6	0.15	0.11	0.47	0.20		13.48a	10.54a	228a	8.88a
5/21/2002	1455	1	JC Boyle Reservoir at Dam		0.9	0.22	0.11	0.48	0.16		14.00	8.70	229	8.20

Date Sampled	Time	Depth, m	Site Name	Total Alk mg/L	Total Kjeldahl Nitrogen mg/L	Ammonia as N mg/L	Nitrate+Nitrite as N mg/L	Total Phos-phorous as P mg/L	Ortho Phosphate as P mg/L	Bio-chemical Oxygen Demand mg/L	Tw C	DO mg/L	EC µS/cm	pH
5/21/2002	1500	8	JC Boyle Reservoir at Dam		0.8	0.29	0.11	0.37	0.16		13.20	8.60	185	7.80
5/22/2002	810		Klamath River at State Line		0.8	0.08	0.14	0.24	0.13		11.54t	8.52t	240t	8.13t
5/22/2002	850		Shovel Creek	36	0.2	0.06	<0.05	0.19	0.10	<3				
5/22/2002	920		Klamath R above Copco		0.7	0.12	0.09	0.26	0.14		11.74b	10.22b	231b	8.55b
5/22/2002	1043	1	JC Boyle Reservoir at Dam	60	0.7	0.08	0.09	0.20	0.13	<3	13.60	11.84	174	7.70
5/22/2002	1045		Klamath R above Shovel Creek	64	0.7	0.08	0.11	0.18	0.14	<3				
5/22/2002	1048	8	JC Boyle Reservoir at Dam	58	0.8	0.11	0.09	0.20	0.13	<3	12.80	11.26	158	7.60
5/22/2002	1143		Klamath R above Irongate Reservoir	67	0.6	0.08	<0.05	0.13	0.11	<3	14.62	8.99	151	8.24
5/22/2002	1205		Klamath R below JC Boyle Dam	60	0.9	0.09	0.11	0.25	0.14	<3	13.30	10.10	168	8.60
5/22/2002	1213		Fall Creek	75	<0.2	<0.05	0.06	0.44	0.11	<3	10.24	10.72	103	8.15
5/22/2002	1233		Jenny Creek	60	0.2	0.05	<0.05	0.10	0.09	<3	10.75	10.80	93	8.23
5/22/2002	1238		Klamath R Bypass Reach above Powerhouse	69	0.3	0.06	0.14	0.20	0.15	<3	12.50	11.00	143	9.40
5/22/2002	1247		JC Boyle Powerhouse Release	60	0.8	0.08	0.09	0.24	0.13	<3	13.30	10.00	166	9.00
5/22/2002	1303		Klamath R below Irongate Dam	65	0.6	0.06	<0.05	0.19	0.10	<3	14.67	10.55	139	8.53
5/22/2002	1318		Spencer Creek	40	0.1	<0.05	<0.05	0.08	0.06	<3	11.90	10.60	70	9.70
5/22/2002	1344		Klamath R above JC Boyle Reservoir	56	0.8	0.06	0.09	0.24	0.45	<3	14.70	11.10	155	9.40
5/22/2002	1350		Klamath River at State Line		0.7	0.09	0.09	0.19	0.13		13.76t	9.1t	228t	8.68t
5/22/2002	1415		Klamath R below Keno Dam	60	0.9	0.06	<0.05	0.28	0.14	<3	13.10	10.70	161	8.70
5/22/2002	1425		Shasta R	292	0.7	0.06	<0.05	0.48	0.31	<3	16.66	11.97	483	8.83
5/22/2002	1445		Mouth of Link R	45	0.8	0.06	<0.05	0.17	0.10	<3	13.40	10.60	103	9.20
5/22/2002	1455		Klamath R above Copco		0.6	0.09	0.08	0.25	0.15		13.95t	10.71t	218t	9.01t
5/22/2002	1500		Klamath R above Shasta	68	0.7	0.06	<0.05	0.16	0.10	<3	17.03	11.22	151	8.81
5/22/2002	1507		Klamath Lake above Link Dam	43	0.7	<0.05	<0.05	0.12	0.08	<3	13.60	10.50	102	9.10
5/23/2002	325	25	Copco Reservoir at Dam	64	1.0	0.33	0.24	0.38	0.25	4	9.51	1.10	130	7.16
5/23/2002	557	1	Copco Reservoir at Dam	66	0.7	<0.05	<0.05	0.21	0.09	<3	14.88	9.60	151	8.64
5/23/2002	612	12	Copco Reservoir at Dam	65	0.5	0.07	0.08	0.22	0.11	<3	13.57	7.48	146	7.93
5/23/2002	656	1	JC Boyle Reservoir at Dam		0.8	0.07	0.09	0.27	0.14		13.40	12.40	156	8.00
5/23/2002	702	8	JC Boyle Reservoir at Dam		0.7	0.05	0.10	0.16	0.07		13.10	11.10	154	7.70
5/23/2002	745		Klamath River at State Line		0.7	0.06	0.11	0.22	0.12		11.57b	8.36b	225b	8.08b
5/23/2002	752	1	Irongate Reservoir above Dam	66	0.6	<0.05	<0.05	0.44	0.08	<3	15.01	10.39	142	8.79

Date Sampled	Time	Depth, m	Site Name	Total Alk mg/L	Total Kjeldahl Nitrogen mg/L	Ammonia as N mg/L	Nitrate+Nitrite as N mg/L	Total Phos-phorous as P mg/L	Ortho Phosphate as P mg/L	Bio-chemical Oxygen Demand mg/L	Tw C	DO mg/L	EC µS/cm	pH
5/23/2002	807	12	Irongate Reservoir above Dam	65	0.4	<0.05	0.15	0.27	0.15	<3	13.57	7.48	146	7.93
5/23/2002	815	30	Irongate Reservoir above Dam	32	0.7	<0.05	0.34	0.24	0.15	<3	9.47	0.78	130	7.13
5/23/2002	822		Klamath R below JC Boyle Dam		0.8	<0.05	<0.05	0.21	0.08		13.20	9.30	156	8.10
5/23/2002	830		Shovel Creek		0.3	0.05	<0.05	0.24	0.09					
5/23/2002	856		Klamath R Bypass Reach above Powerhouse		0.7	<0.05	0.10	0.25	0.13		10.90	10.80	139	9.10
5/23/2002	900		JC Boyle Powerhouse Release		0.3	<0.05	0.14	0.35	0.14		13.10	10.20	154	8.80
5/23/2002	900		Klamath R above Copco		0.9	0.06	0.06	0.21	0.12		11.41	10.09	219	8.44
5/23/2002	1058		Spencer Creek		0.9	0.10	0.08	0.23	0.13		9.40	10.70	71	9.40
5/23/2002	1128		Klamath R above JC Boyle Reservoir		0.2	<0.05	<0.05	0.16	0.06		14.00	9.90	229	9.80
5/23/2002	1205		Klamath R below Keno Dam		0.9	<0.05	0.11	0.24	0.16		13.00	10.10	248	9.80
5/23/2002	1249		Mouth of Link R		1.1	<0.05	<0.05	0.30	0.17		13.40	10.30	103	9.40
5/23/2002	1304		Klamath Lake above Link Dam		0.7	<0.05	<0.05	0.22	0.09		13.10	9.80	101	9.60
6/18/2002	1015		Klamath R below JC Boyle Dam	88	1.1	0.15	0.24	0.38	0.25	<3	19.09	8.12	225	8.34
6/18/2002	1113		Klamath R Bypass Reach above Powerhouse	74	0.8	0.12	0.23	0.24	0.16	<3	13.80	9.78	139	8.23
6/18/2002	1119		JC Boyle Powerhouse Release	97	1.8	0.20	0.26	0.35	0.24	<3	18.97	7.53	227	8.12
6/18/2002	1154		Spencer Creek	58	0.2	0.03	<0.05	0.14	0.08	4	17.16	8.67	98	8.11
6/18/2002	1219		Klamath R above JC Boyle Reservoir	93	1.3	0.07	0.27	0.36	0.24	4	18.88	8.80	233	8.66
6/18/2002	1255		Klamath R below Keno Dam	92	1.6	0.15	<0.05	0.38	0.21	6	18.33	8.76	228	8.87
6/18/2002	1427	1	JC Boyle Reservoir at Dam	88	1.0	0.08	0.17	0.35	0.23	4	20.56	9.19	227	8.78
6/18/2002	1436	8	JC Boyle Reservoir at Dam	92	1.3	0.17	0.27	0.36	0.24	3	18.46	6.76	234	8.10
6/19/2002	1043		Klamath R above Shovel Creek	88	1.2	0.11	0.24	0.32	0.22	<3	16.66	10.18	197	8.46
6/19/2002	1207	1	Copco Reservoir at Dam	77	1.1	0.12	<0.05	0.37	0.17	5	20.11	9.12	182	8.58
6/19/2002	1219	9	Copco Reservoir at Dam	75	1.0	0.18	0.07	0.30	0.14	2	18.13	7.19	174	8.22
6/19/2002	1231	25	Copco Reservoir at Dam	71	1.1	0.24	0.43	0.36	0.29	<3	11.09	0.27	135	7.20
6/19/2002	1340		Klamath R above Irongate Reservoir	78	1.0	0.11	0.08	0.34	0.18	<3	19.41	9.16	177	8.43
6/19/2002	1352		Fall Creek	76	0.5	0.10	0.09	0.21	0.07	<3	12.71	10.19	95	8.15
6/19/2002	1406		Jenny Creek	82	0.1	0.10	<0.05	0.14	0.03	<3	16.72	9.44	143	8.40
6/19/2002	1501	1	Irongate Reservoir above Dam	77	1.0	0.10	<0.05	0.32	0.15	3	22.21	9.70	190	8.58
6/19/2002	1507	15	Irongate Reservoir above Dam	72	1.0	0.10	0.06	0.19	0.14	4	18.28	7.52	172	8.16
6/19/2002	1530	30	Irongate Reservoir above Dam	70	1.0	0.13	0.69	0.26	0.18	<3				

Date Sampled	Time	Depth, m	Site Name	Total Alk mg/L	Total Kjeldahl Nitrogen mg/L	Ammonia as N mg/L	Nitrate+Nitrite as N mg/L	Total Phos-phorous as P mg/L	Ortho Phosphate as P mg/L	Bio-chemical Oxygen Demand mg/L	Tw C	DO mg/L	EC µS/cm	pH
6/19/2002	1645		Klamath R below Irongate Dam	68	1.1	0.10	<0.05	0.21	0.13	3	20.13	9.41	184	8.23
6/19/2002	1822		Klamath R above Shasta	78	1.0	0.04	<0.05	0.24	0.13	<3	22.22	10.25	186	9.11
6/19/2002	1845		Shasta R	284	1.0	0.04	<0.05	0.47	0.32	3	23.72	7.98	556	8.76
7/15/2002	1445		Klamath R above Copco		0.5	0.05	0.37	0.18	0.20		22.20	7.20	113	8.37
7/15/2002	1630		Klamath River at State Line		0.8	0.13	0.65	0.23	0.23		21.44	6.46	111	8.26
7/16/2002	815		Klamath River at State Line		<0.2	0.04	0.49	0.16	0.20		18.29	6.84	110	7.62
7/16/2002	900		Klamath R above Shovel Creek	62	0.6	0.05	0.62	0.26	0.23	3	19.80	7.19	114	8.06
7/16/2002	1032	1	Copco Reservoir at Dam	73	1.2	0.04	<0.05	0.21	0.18	8	23.33	11.61	181	9.16
7/16/2002	1040		Klamath R above Copco		0.6	0.05	0.65	0.17	0.24		20.96	7.56	117	8.25
7/16/2002	1056	13	Copco Reservoir at Dam	80	0.4	0.09	0.33	0.71	0.29	3	17.80	1.89	2	7.60
7/16/2002	1056	25	Copco Reservoir at Dam	72	0.7	0.42	0.07	0.46	0.45	5	11.60	0.11	141	7.12
7/16/2002	1102	1	JC Boyle Reservoir at Dam	58	1.0	0.12	0.72	0.29	0.27	3				
7/16/2002	1110	8	JC Boyle Reservoir at Dam	58	1.2	0.23	0.75	0.28	0.27	4				
7/16/2002	1136		Klamath R above Irongate Reservoir	71	0.7	0.06	0.14	0.19	0.22	4	21.76	7.60	182	8.53
7/16/2002	1138		Klamath R below JC Boyle Dam	58	1.1	0.27	0.76	0.27	0.28	5	23.90		132	
7/16/2002	1201		Fall Creek	74	0.2	<0.05	0.06	0.11	0.10	4	12.51	10.57	111	8.18
7/16/2002	1230		Klamath River at State Line		0.3	0.05	0.38	0.14	0.18		18.05	7.45	106	8.26
7/16/2002	1233		Jenny Creek	90	<0.2	<0.05	<0.05	<0.05	0.09	2	20.80	8.99	187	8.25
7/16/2002	1257		Klamath R Bypass Reach above Powerhouse	64	0.2	0.03	0.40	0.15	0.17	<3	16.40		139	
7/16/2002	1304		JC Boyle Powerhouse Release	58	1.1	0.21	0.78	0.27	0.27	3	23.90		130	
7/16/2002	1315		Shovel Creek	58	<0.2	0.09	0.08	0.09	0.12	<3	17.04	7.91	71	7.89
7/16/2002	1321	1	Irongate Reservoir above Dam	79	0.5	<0.05	<0.05	0.12	0.14	4	26.22	10.53	217	9.04
7/16/2002	1338	12	Irongate Reservoir above Dam	66	0.3	0.11	0.17	0.13	0.13	3	15.14	3.79	151	7.54
7/16/2002	1352	30	Irongate Reservoir above Dam	66	0.4	<0.05	0.61	0.14	0.19	<3	7.05	1.84	125	7.24
7/16/2002	1405		Spencer Creek	64	<0.2	<0.05	<0.05	<0.05	0.07	<3	22.90		114	
7/16/2002	1415		Klamath R above Copco		0.5	0.07	0.37	0.21	0.21		21.00	6.86	110	8.49
7/16/2002	1431		Klamath R above JC Boyle Reservoir	56	1.0	0.11	0.91	0.25	0.25	3				
7/16/2002	1510		Klamath R below Keno Dam	60	2.3	0.48	0.05	0.31	0.18	5	24.10			
7/16/2002	1513		Klamath R below Irongate Dam	77	0.6	0.06	0.10	0.18	0.18	3	22.16	9.13	196	8.38
7/16/2002	1550		Klamath R above Shasta	75	0.4	0.06	0.07	0.15	0.18	4	24.92	10.71	207	8.81

Date Sampled	Time	Depth, m	Site Name	Total Alk mg/L	Total Kjeldahl Nitrogen mg/L	Ammonia as N mg/L	Nitrate+Nitrite as N mg/L	Total Phos-phorous as P mg/L	Ortho Phosphate as P mg/L	Bio-chemical Oxygen Demand mg/L	Tw C	DO mg/L	EC µS/cm	pH
7/16/2002	1619		Shasta R	246	0.5	0.08	<0.05	0.30	0.38	3	28.57	8.49	578	8.77
7/17/2002	815		Klamath River at State Line		0.5	0.07	0.47	0.19	0.18		18.08	7.50	110	7.64
7/17/2002	930	1	JC Boyle Reservoir at Dam		1.4	0.15	0.69	0.42			24.20	5.90		
7/17/2002	934	9	JC Boyle Reservoir at Dam		1.3	0.24	0.75	0.37	0.24		23.00	3.90		
7/17/2002	945		Klamath R above Copco		0.8	0.11	0.66	0.23	0.20		20.63	7.90	120	7.98
7/17/2002	1004		Klamath R below JC Boyle Dam		1.3	0.15	0.74	0.53	0.23		23.50			
7/17/2002	1109		Klamath R Bypass Reach above Powerhouse		0.4	0.14	0.40	0.29	0.14		16.30	8.70		
7/17/2002	1112		JC Boyle Powerhouse Release		1.3	0.18	0.76	0.51	0.27		23.10	6.10		
7/17/2002	1201		Klamath R above JC Boyle Reservoir		1.2	<0.05	0.98	0.50	0.21		24.20			
7/17/2002	1230		Klamath R below Keno Dam		1.4	0.68	0.05	0.42	0.16		23.80	6.60		
7/17/2002	1250		Klamath River at State Line		0.5	0.07	0.37	0.13	0.15		17.95	7.89	105	8.42
7/17/2002	1415		Klamath R above Copco		0.5	0.11	0.39	0.17	0.16		21.07	8.09	110	8.63
7/17/2002	1500		Klamath Lake above Link Dam		2.0	0.25	0.06	0.62	0.11		24.00	5.70		
7/17/2002	1515		Mouth of Link R		2.0	0.23	0.11	0.55	0.10		24.80	6.40		
7/18/2002	625	1	JC Boyle Reservoir at Dam		1.6	0.12	0.67	0.30	0.21		24.20	6.70		
7/18/2002	628	9	JC Boyle Reservoir at Dam		1.6	0.26	0.75	0.30	0.24		22.70	4.30		
7/18/2002	715		Klamath R below JC Boyle Dam		1.5	0.21	0.76	0.28	0.24		22.80			
7/18/2002	755		JC Boyle Powerhouse Release		1.7	0.28	0.76	0.33	0.23		21.80	5.30		
7/18/2002	800		Klamath River at State Line		0.6	0.11	0.51	0.57	0.17		18.62	6.84	104	7.67
7/18/2002	805		Klamath R Bypass Reach above Powerhouse		0.5	0.05	0.37	0.16	0.13		14.50	8.70		
7/18/2002	915		Klamath R above Copco		0.8	0.12	0.70	0.54	0.20		20.57	7.35	119	8.06
7/18/2002	930		Klamath R above JC Boyle Reservoir		1.8	0.11	1.05	0.30	0.23		21.70	7.20		
7/18/2002	1017		Klamath R below Keno Dam		<0.2	0.60	0.08	0.27	0.19		23.20	6.30		
7/18/2002	1100		Mouth of Link R		2.0	0.28	0.18	0.18	0.11			6.20		
7/18/2002	1127		Klamath Lake above Link Dam		2.1	0.24	0.10	0.18	0.09		24.70	5.00		
8/13/02	915		Klamath R below JC Boyle Dam	72	1.7	0.27	0.82	0.30	0.30	3	20.09	7.85	184	7.94
8/13/02	1018		Klamath R Bypass Reach above Powerhouse	65	0.5	0.10	0.36	0.15	0.19	3	13.92	9.74	127	8.26
8/13/02	1024		JC Boyle Powerhouse Release	70	1.6	0.22	0.73	0.29	0.29	4	19.34	7.35	179	7.86
8/13/02	1122		Spencer Creek	66	0.1	0.04	<0.05	0.05	0.06	<3	16.90	8.66	108	8.21
8/13/02	1148		Klamath R above JC Boyle Reservoir	72	1.8	0.09	0.71	0.28	0.29	5	21.01	8.36	199	8.48

Date Sampled	Time	Depth, m	Site Name	Total Alk mg/L	Total Kjeldahl Nitrogen mg/L	Ammonia as N mg/L	Nitrate+Nitrite as N mg/L	Total Phos-phorous as P mg/L	Ortho Phosphate as P mg/L	Bio-chemical Oxygen Demand mg/L	Tw C	DO mg/L	EC µS/cm	pH
8/13/02	1221		Klamath R below Keno Dam	75	2.1	0.64	0.13	0.28	0.24	5	20.56	7.46	203	8.15
8/13/02	1316	1	JC Boyle Reservoir at Dam	72	1.7	0.39	0.66	0.30	0.29	5	22.19	6.64	196	7.91
8/13/02	1331	8	JC Boyle Reservoir at Dam	73	1.7	0.45	0.76	0.25	0.30	5	18.85	4.80	183	7.66
8/14/2002	1025		Klamath R above Shovel Creek	66	0.6	0.10	0.49	0.11	0.20	<3	18.00	10.12	150	8.38
8/14/2002	1037		Shovel Creek	61	0.1	0.07	<0.05	0.06	0.12	<3	14.86	9.88	98	8.10
8/14/2002	1151	1	Copco Reservoir at Dam	71	0.9	0.14	0.35	0.14	0.18	4	21.84	9.25	163	8.60
8/14/2002	1209	17	Copco Reservoir at Dam	74	0.2	0.33	0.05	0.29	0.58	3	16.62	1.16	159	7.58
8/14/2002	1216	25	Copco Reservoir at Dam	70	1.2	1.04	<0.05	0.53	0.18	7	11.90	0.09	149	7.23
8/14/2002	1306		Klamath R above Irongate Reservoir	70	0.7	0.21	0.38	0.17	0.22	3	20.34	6.97	159	8.10
8/14/2002	1321		Fall Creek	73	0.2	0.08	0.07	0.03	0.08	7	13.33	10.56	113	8.04
8/14/2002	1339		Jenny Creek	70	0.3	0.08	<0.05	<0.05	0.07	<3	20.68	8.95	182	8.63
8/14/2002	1427	1	Irongate Reservoir above Dam	70	2.1	0.12	<0.05	0.17	0.11	14	25.09	16.85	190	9.70
8/14/2002	1442	12	Irongate Reservoir above Dam	70	0.7	0.11	0.45	0.17	0.25	<3	19.05	0.53	172	7.60
8/14/2002	1457	30	Irongate Reservoir above Dam	70	0.6	0.09	0.69	0.11	0.19	<3	7.14	0.10	125	7.25
8/14/2002	1557		Klamath R below Irongate Dam	72	1.2	0.14	0.15	0.16	0.15	8	22.42	10.50	177	9.16
8/14/2002	1642		Klamath R above Shasta	75	0.9	0.13	0.22	0.12	0.18	5	23.79	10.39	158	8.80
8/14/2002	1701		Shasta R	302	0.7	0.11	<0.05	0.28	0.41	4	27.62	9.32	667	8.91
9/9/2002	1400		Klamath River at State Line		0.4	0.09	0.16	0.14	0.42		14.90	9.45	176	8.14
9/9/2002	1515		Klamath R above Copco		0.5	0.08	0.16	0.12	0.41		13.72	9.01	178	7.88
9/10/2002	815		Klamath River at State Line		0.6	0.07	0.18	0.03	0.27		13.28	7.81	191	7.58
9/10/2002	910		Klamath R above Shovel Creek	70	0.9	0.08	0.13	0.16	0.14	2	14.00	8.47	224	7.78
9/10/2002	915	1	Copco Reservoir at Dam	78	0.7	0.07	0.26	0.23	0.19	5	18.51	7.66	202	8.50
9/10/2002	925	25	Copco Reservoir at Dam	84	1.4	0.95	<0.05	0.69	0.59	8	12.42	0.10	201	7.38
9/10/2002	930	14	Copco Reservoir at Dam	80	0.8	0.32	0.26	0.27	0.23	6	16.85	2.22	208	7.79
9/10/2002	950		Klamath R Bypass Reach above Powerhouse	80	<0.2	0.05	0.16	0.12	0.09	<3	12.20	9.65	137	8.21
9/10/2002	1005		JC Boyle Powerhouse Release	94	1.2	0.12	0.16	0.27	0.15	3	14.60	8.64	203	8.38
9/10/2002	1020		Klamath R above Irongate Reservoir	80	0.8	0.11	0.31	0.25	0.18	6	18.10	7.18	108	8.05
9/10/2002	1035		Klamath R above Copco		0.9	0.09	0.14	0.13	0.29		15.00	8.58	246	7.86
9/10/2002	1035		Klamath R below JC Boyle Dam	100	1.7	0.14	0.14	0.28	0.19	<3	16.80	8.78	248	8.48
9/10/2002	1045		Fall Creek	74	<0.2	0.09	0.07	0.03	<0.03	2	10.10	11.39	143	8.31

Date Sampled	Time	Depth, m	Site Name	Total Alk mg/L	Total Kjeldahl Nitrogen mg/L	Ammonia as N mg/L	Nitrate+Nitrite as N mg/L	Total Phos-phorous as P mg/L	Ortho Phosphate as P mg/L	Bio-chemical Oxygen Demand mg/L	Tw C	DO mg/L	EC µS/cm	pH
9/10/2002	1100		Jenny Creek	92	0.1	0.08	<0.05	0.08	<0.03	<3	13.04	10.60	192	8.51
9/10/2002	1135		Spencer Creek	62	0.3	0.04	<0.05	0.08	<0.03	<3	10.60	10.16	77	8.04
9/10/2002	1158	1	Irongate Reservoir above Dam	74	1.1	0.08	0.13	0.16	0.16	3	20.51	10.32	180	9.10
9/10/2002	1159		Klamath R above JC Boyle Reservoir	102	2.1	0.13	0.13	0.23	0.19	3	18.10	8.33	256	8.78
9/10/2002	1220		Klamath River at State Line		0.5	0.06	0.15	0.15	0.26		13.56	7.74	176	8.03
9/10/2002	1225	30	Irongate Reservoir above Dam	72	0.6	0.20	0.43	0.14	<0.03	3	7.34	0.06	193	7.36
9/10/2002	1230	16	Irongate Reservoir above Dam	90	0.4	0.08	0.19	0.21	0.15	6	14.97	0.15	188	7.51
9/10/2002	1234		Klamath R below Keno Dam	104	2.0	0.21	<0.05	0.29	0.17	5	17.40	8.97	250	8.98
9/10/2002	1300		Shovel Creek	64	0.1	0.07	0.05	0.07	0.26	<3	13.75	8.75	80	7.56
9/10/2002	1340		Klamath R below Irongate Dam	74	0.7	0.08	0.24	0.17	0.12	3	19.34	8.69	181	8.36
9/10/2002	1352	1	JC Boyle Reservoir at Dam	104	2.2	0.29	0.05	0.29	0.20	5	19.10	11.45	264	8.99
9/10/2002	1358	7	JC Boyle Reservoir at Dam	104	2.1	0.21	0.12	0.27	0.19	3	16.30	6.66	244	8.37
9/10/2002	1400		Klamath R above Shasta	76	0.6	0.19	0.23	0.17	0.13	<3	20.10	11.14	181	8.44
9/10/2002	1430		Klamath R above Copco		0.6	0.10	0.14	0.17	0.27		15.48	8.52	181	8.58
9/10/2002	1445		Shasta R	260	0.4	<0.05	0.05	0.26	0.19	4	19.62	10.37	567	8.75
9/11/2002	800		Klamath River at State Line		0.9	0.09	0.17	0.15	0.14		14.49	6.58	251	7.24
9/11/2002	838		Klamath R above JC Boyle Reservoir		1.5	0.22	0.24	0.27	0.19		15.20	8.08	234	8.14
9/11/2002	906		Klamath R below JC Boyle Dam		1.5	0.31	0.10	0.26	0.21		16.60	8.33	249	8.58
9/11/2002	945		Klamath R above Copco		1.1	0.09	0.11	0.17	0.13		15.00	7.61	281	7.95
9/11/2002	950	1	JC Boyle Reservoir at Dam		1.6	0.50	0.05	0.30	0.18		17.20	10.23	252	8.93
9/11/2002	958	7	JC Boyle Reservoir at Dam		1.6	0.43	0.09	0.22	0.18		16.40	6.21	248	8.33
9/11/2002	1113		Klamath R Bypass Reach above Powerhouse		0.4	0.08	0.15	0.12	0.08		13.00	9.76	142	8.34
9/11/2002	1120		JC Boyle Powerhouse Release		1.1	0.41	0.10	0.20	0.18		16.10	10.20	216	8.73
9/11/2002	1158		Klamath R below Keno Dam		2.0	0.22	<0.05	0.26	0.18		17.40	8.58	240	9.03
9/11/2002	1200		Klamath River at State Line		0.4	0.07	0.16	0.09	0.10		14.68	7.79	190	7.86
9/11/2002	1232		Mouth of Link R		1.8	0.23	0.06	0.17	0.12		18.20	8.89	92	9.55
9/11/2002	1250		Klamath Lake above Link Dam		1.9	0.23	<0.05	0.18	0.15		17.50	11.03	90	9.49
9/11/2002	1345		Klamath R above Copco		0.8	0.26	0.11	0.17	0.14		17.28	8.72	260	8.69
9/12/2002	800		Klamath River at State Line		0.4	0.13	0.13	0.14	0.21		13.34	6.55	181	8.09
9/12/2002	817	1	JC Boyle Reservoir at Dam		1.5	0.29	<0.05	0.21	0.18		17.40	11.85	252	7.58

Date Sampled	Time	Depth, m	Site Name	Total Alk mg/L	Total Kjeldahl Nitrogen mg/L	Ammonia as N mg/L	Nitrate+Nitrite as N mg/L	Total Phos-phorous as P mg/L	Ortho Phosphate as P mg/L	Bio-chemical Oxygen Demand mg/L	Tw C	DO mg/L	EC µS/cm	pH
9/12/2002	822	8	JC Boyle Reservoir at Dam		1.5	0.26	0.08	0.19	0.17		16.40	5.98	251	8.31
9/12/2002	852		Klamath R below JC Boyle Dam		1.6	0.24	0.08	0.23	0.18		16.80	8.32	251	8.64
9/12/2002	915		Klamath R above Copco		0.5	0.09	0.11	0.12	0.21		14.47	8.57	184	8.13
9/12/2002	1020		Klamath R Bypass Reach above Powerhouse		0.3	0.05	0.15	0.08	0.08		12.60	9.78	140	8.27
9/12/2002	1030		JC Boyle Powerhouse Release		0.9	0.21	0.10	0.23	0.18		16.20	8.41	235	8.53
9/12/2002	1122		Klamath R above JC Boyle Reservoir		1.5	0.11	0.19	0.17	0.20		17.40	8.38	236	8.42
9/12/2002	1154		Klamath R below Keno Dam		1.6	0.14	<0.05	0.23	0.21		17.70	8.49	235	9.03
9/12/2002	1226		Mouth of Link R		2.2	0.17	0.08	0.14	0.14		19.40	8.66	96	9.52
9/12/2002	1245		Klamath Lake above Link Dam		2.1	0.17	0.05	0.11	0.13		18.60	11.74	93	9.54
10/8/2002	1027	1	JC Boyle Reservoir at Dam	80	2.1	0.27	0.54	0.22	0.08	6	13.70	8.72	222	7.11
10/8/2002	1030	8	JC Boyle Reservoir at Dam	77	1.6	0.40	0.53	0.21	0.10	5	12.70	7.35	195	7.11
10/8/2002	1150		Klamath R Bypass Reach above Powerhouse	73	1.1	0.15	0.65	0.11	0.09	<3	13.00	8.24	162	7.40
10/8/2002	1244		Klamath R below JC Boyle Dam	75	1.7	0.34	0.57	0.19	0.09	5	13.80	7.90	182	7.40
10/8/2002	1350		Spencer Creek	61	<0.2	<0.05	<0.05	<0.05	<0.03	5	10.10	8.64	115	7.50
10/8/2002	1446		Klamath R above JC Boyle Reservoir	72	1.7	0.26	0.59	0.15	0.09	4	14.80	7.14	165	7.40
10/8/2002	1629		Klamath R below Keno Dam	72	2.5	0.37	0.13	0.03	0.05	7	14.40	7.99	131	7.70
10/9/2002	925		Klamath R above Shovel Creek	73	0.8	0.07	0.76	0.11	0.10	5	11.70	9.04	163	7.50
10/9/2002	1000		Shovel Creek	82	0.1	0.03	0.08	0.06	0.05	<3	8.60	9.73	118	7.40
10/9/2002	1112		Klamath R below Irongate Dam	81	0.5	0.08	0.17	0.18	0.16	<3	16.10	6.94	204	7.50
10/9/2002	1215	1	Irongate Reservoir above Dam	100	0.6	0.07	0.09	0.16	0.12	<3	17.20	12.20	184	8.40
10/9/2002	1225	8	Irongate Reservoir above Dam	<10	0.7	0.13	0.23	0.20	0.17	3	15.70	6.31	183	8.30
10/9/2002	1235	30	Irongate Reservoir above Dam	72	0.5	0.20	0.43	0.17	0.18	<3	7.90	0.17	157	8.40
10/9/2002	1411		Klamath R above Irongate Reservoir	83	0.8	0.14	0.25	0.23	0.20	<3	14.90	5.98	204	7.40
10/9/2002	1424		Fall Creek	74	0.2	0.10	0.09	0.06	0.04	<3	11.10	8.64	138	7.50
10/9/2002	1505	1	Copco Reservoir at Dam	84	0.8	0.08	0.26	0.16	0.17	3	16.50	9.66	186	8.57
10/9/2002	1510	10	Copco Reservoir at Dam	80	0.7	0.10	0.26	0.15	0.12	<3	14.60	6.82	180	8.46
10/9/2002	1515	26	Copco Reservoir at Dam	84	1.5	1.01	<0.05	0.58	0.62	5	12.90	0.32	176	8.53
10/9/2002	1615		Jenny Creek	99	0.1	0.06	<0.05	<0.05	0.04	4	13.10	8.52	194	7.70
10/9/2002	1820		Shasta R	214	0.3	0.21	0.11	0.19	0.18	<3	15.60	7.20	435	7.60
10/9/2002	1845		Klamath R above Shasta	80	0.5	0.09	0.21	0.15	0.16	3	17.30	8.16	202	7.70

Date Sampled	Time	Depth, m	Site Name	Total Alk mg/L	Total Kjeldahl Nitrogen mg/L	Ammonia as N mg/L	Nitrate+Nitrite as N mg/L	Total Phos-phorous as P mg/L	Ortho Phosphate as P mg/L	Bio-chemical Oxygen Demand mg/L	Tw C	DO mg/L	EC µS/cm	pH
11/12/2002	820		Klamath R below Keno Dam	62	1.5	0.55	0.22	0.14	0.12	4	5.35	11.94	144	7.75
11/12/2002	845		Klamath R above JC Boyle Reservoir	58	1.2	0.20	0.73	0.17	0.11	<3	5.33	12.07	143	7.84
11/12/2002	912		Spencer Creek	55	0.2	0.03	<0.05	0.04	<0.03	<3	3.07	12.73	105	7.73
11/12/2002	948		Klamath R Bypass Reach above Powerhouse	63	0.4	0.07	0.43	0.09	0.07	<3	9.01	11.89	144	8.07
11/12/2002	1002		JC Boyle Powerhouse Release	58	1.2	0.29	0.65	0.13	0.08	<3	6.28	11.35	144	7.68
11/12/2002	1052		Klamath R below JC Boyle Dam	55	1.0	0.30	0.72	0.16	0.12	<3	5.78	12.49	144	7.76
11/12/2002	1237	1	JC Boyle Reservoir at Dam	54	1.3	0.31	0.69	0.14	0.10	3	5.95	11.00	144	7.72
11/12/2002	1242	8	JC Boyle Reservoir at Dam	58	1.3	0.32	0.64	0.19	0.11	<3	5.64	11.11	144	7.68
11/13/2002	811		Klamath R above Shovel Creek	60	0.7	0.08	0.78	0.11	0.11	6	6.73	11.34	146	7.87
11/13/2002	815		Shovel Creek	63	<0.2	0.04	<0.05	0.07	0.06	<3	6.69	11.22	124	7.86
11/13/2002	1036	1	Copco Reservoir at Dam	74	0.8	0.15	0.48	0.14	0.12	5	8.53	10.06	181	7.83
11/13/2002	1041	10	Copco Reservoir at Dam	75	0.9	0.16	0.48	0.21	0.12	<3	8.27	9.95	181	7.83
11/13/2002	1046	28	Copco Reservoir at Dam	71	0.9	0.21	0.52	0.15	0.13	<3	7.65	9.14	175	7.68
11/13/2002	1200		Klamath R above Irongate Reservoir	75	0.7	0.20	0.51	0.15	0.15	3	8.35	10.78	180	7.77
11/13/2002	1221		Fall Creek	76	<0.2	0.03	<0.05	0.05	0.05	5	8.91	11.74	145	8.15
11/13/2002	1245		Jenny Creek	91	0.1	0.05	<0.05	0.03	0.02	<3	7.18	12.18	205	8.27
11/13/2002	1342	1	Irongate Reservoir above Dam	78	0.7	0.15	0.60	0.16	0.16	<3	10.68	8.04	197	7.72
11/13/2002	1347	10	Irongate Reservoir above Dam	78	1.0	0.17	0.29	0.15	0.16	<3	9.89	8.04	198	7.70
11/13/2002	1352	30	Irongate Reservoir above Dam	76	0.6	0.22	0.34	0.20	0.17	<3	8.85	5.38	191	7.45
11/13/2002	1540		Klamath R below Irongate Dam	78	0.7	0.16	0.30	0.18	0.16	<3	9.95	10.18	197	7.68
11/13/2002	1617		Klamath R above Shasta	82	0.7	0.10	0.33	0.20	0.17	<3	10.56	12.05	198	8.44
11/13/2002	1638		Shasta R	219	0.3	0.06	0.25	0.25	0.28	<3	9.80	11.24	485	8.51

FLAG = *: No flow from JC Boyle PH at time of sample
t = sonde measurement from the top of hour
b = sonde measurement from the bottom of hour was used
a = the average of the top and bottom of hour sonde measurement is presented

G Data Processing for Calibration/Validation

G.1 Computation of Dissolved Oxygen Saturation

Dissolved oxygen saturation concentration is a function of water temperature, atmospheric pressure, and concentration of dissolved solids. The APHA (1985) formulation, namely

$$\ln(O_{sn}) = -139.34411 + (1.575701 \times 10^{5}/T) - (6.642308 \times 10^{7}/T^{2}) + (1.243800 \times 10^{10}/T^{3}) - (8.621949 \times 10^{11}/T^{4})$$

where

O_{sn} = saturation dissolved oxygen at 1 atmosphere (mg l^{-1})

T = water temperature (K)

To correct for atmospheric pressure at elevations less than roughly 4000 feet

$$O_s = O_{sn} P$$

Where

O_s = equilibrium dissolved oxygen concentration at non-standard pressure (mg $^{l-1}$)

P = atmospheric pressure (atm)

To correct for atmospheric pressure at elevations greater than roughly 4000 feet

$$O_s = O_{sn} P \, [(1-(P_{wv}/P)](1- \phi P) / [(1-P_{wv})(1-\phi)]$$

where

P_{wv} = partial pressure of water vapor (atm) computed from,

$$\ln(P_{wv}) = 11.8571 - 3840.70/(T_{a'}) - 216961/(T_{a'})^2$$

where $T_{a'}$ is air temperature (K), and

$$\phi = 0.000975 - 1.425 \times 10^{-5} (T_a) + 6.436 \times 10^{-8} (T_a)^2$$

where T_a is air temperature (°C)

and other parameters are previously defined.

The former representation, for elevations less than approximately 4000 feet, was used in these analyses. Salinity (dissolved solids) can be incorporated in the above formulation, but was not addressed in this analysis.

Daily atmospheric pressure was corrected for elevation using assumed a constant sea level value of 1013 mb as per

$$P = 1013 - 3.436(E/100) - 0.0029(E/100)^2 + 0.0001(E/100)^3$$

Where E is elevation in feet and P is barometric pressure in millibars (U.C. Cooperative Extension, ___).

G.2 Correction for Biofouling Effects on Dissolved Oxygen Observations

Dissolved oxygen data for the calibration period was available from USBR (2003). The data clearly show that biofouling affected field observations (Figure 1). Probes were changes

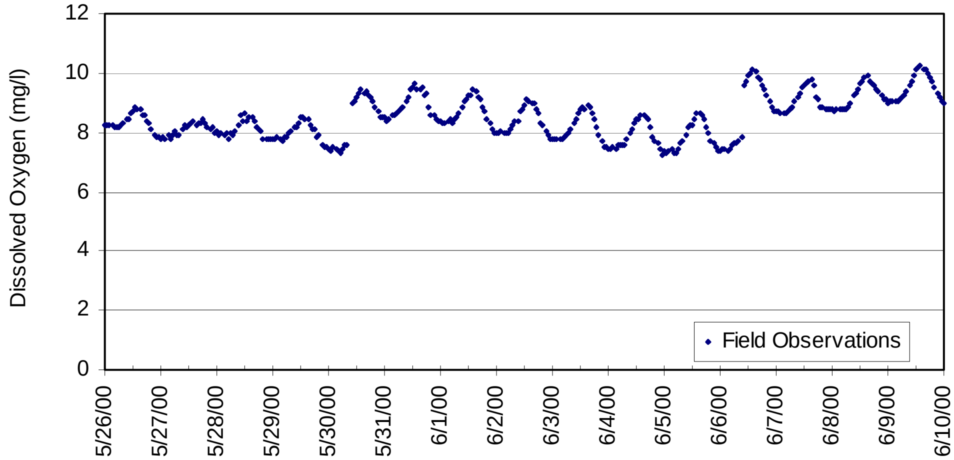


Figure 1. Observed dissolved oxygen at Seiad Valley, May-June 2000

To adjust the observed dissolved oxygen trace it was assumed that upon deployment the "fresh" probes are reading correctly. Using the difference form the last reading on the retrieved probe and the first reading deployed probe the traces were adjusted to provide a reasonable estimate of actual conditions. This method, which distributes the error over the entire period assumes that biolfouling affects probes uniformly from the hour of deployment to the hour of retrieval. Figure 2 shows the final results for the week of May 30 through June 6, 2000. Figure 3 shows the results for August 1-14, 2000.

Similar conditions occurred at the Klamath River at Youngs Bar and were addressed in the same fashion (Figures 4 and 5).

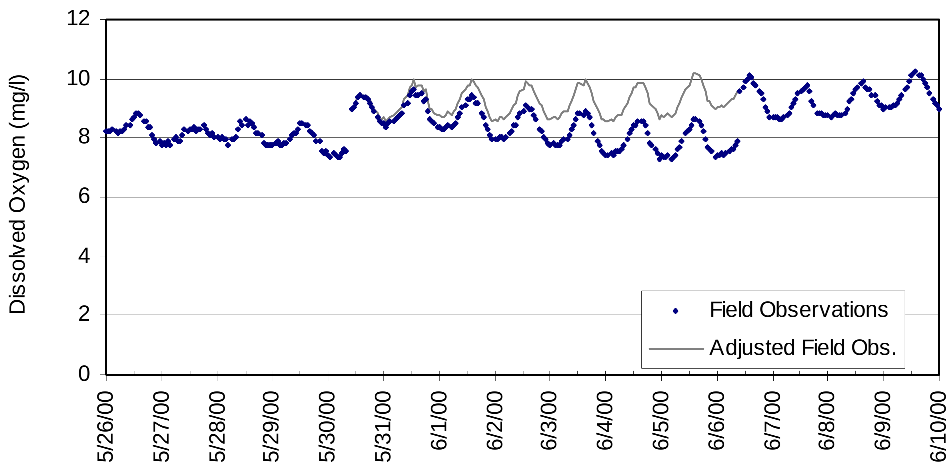


Figure 2. Observed and adjusted dissolved oxygen at Seiad Valley, May-June 2000

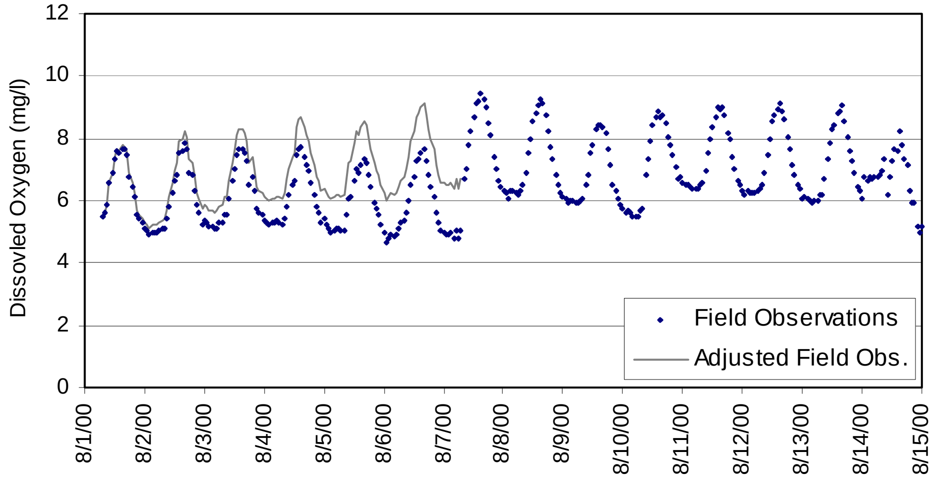


Figure 3. Observed and adjusted dissolved oxygen at Seiad Valley, August 2000

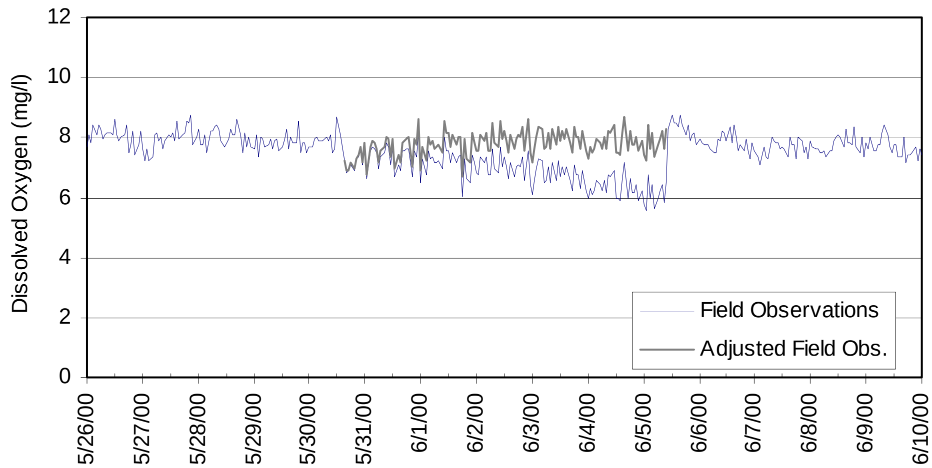


Figure 4. Observed dissolved oxygen at Youngs Bar, May-June 2000

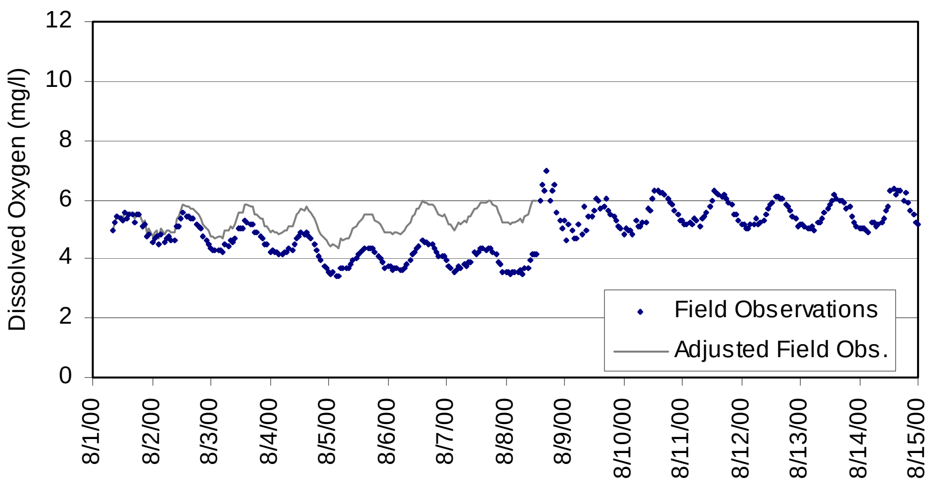


Figure 5. Observed and adjusted dissolved oxygen at Youngs Bar, August 2000

H 2001 Lake Ewauna/Keno Reach Boundary Conditions – Graphical and Tabular Presentation

The data to support the 2001 application of CE-QUAL-W2 to the Lake Ewauna/Keno Reservoir reach was not completed in a time to be included in the main documentation. The reader is referred to the main documentation, section 2.3.2 for the definitions of the various boundary conditions. Certain data are the same for 2001 and for 2000 and are not replicated herein.

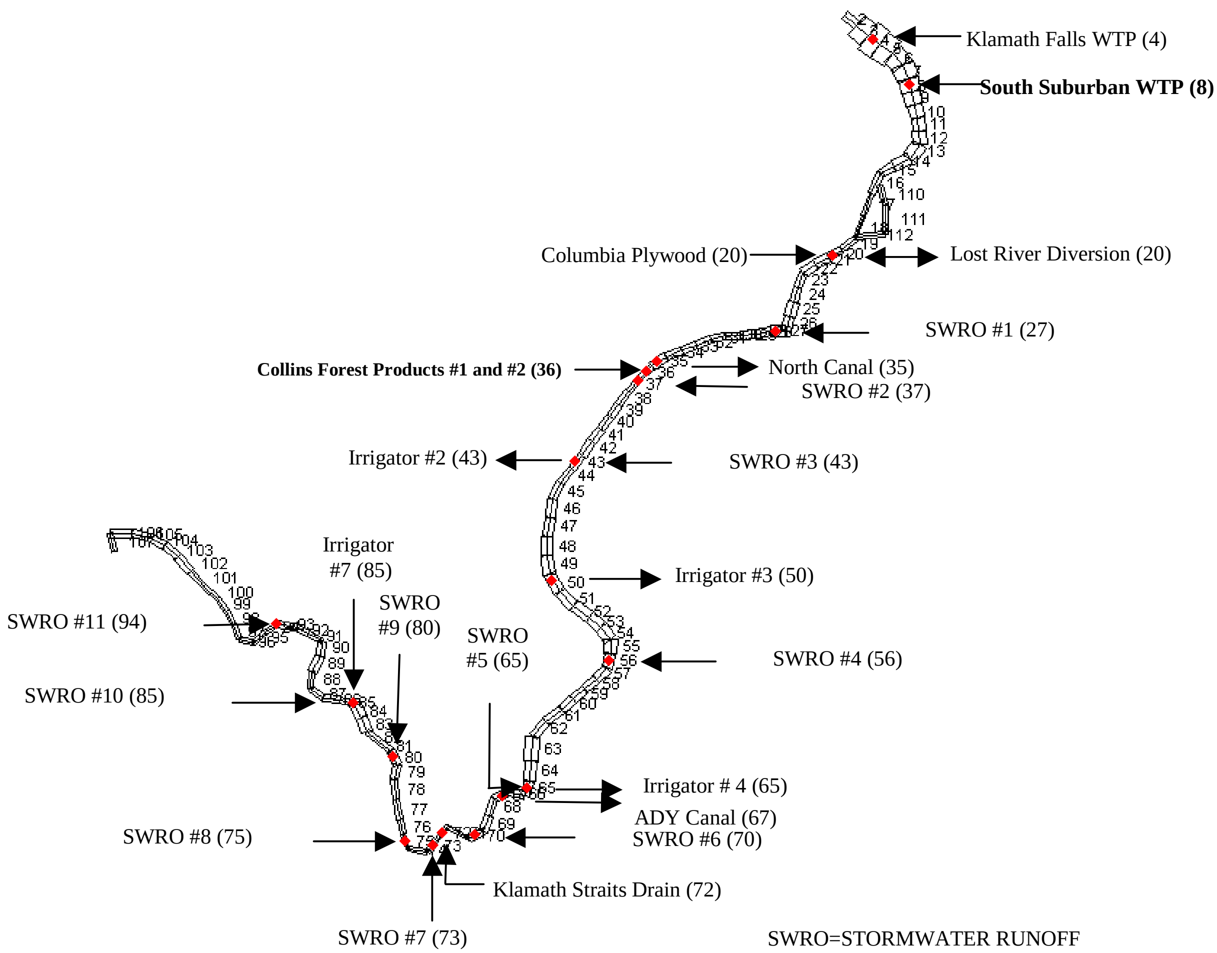


Figure 1. Map of Lake Ewauna to Keno Dam CE-QUAL-W2 presentation, identifying inputs and withdrawals

Link River Inflow

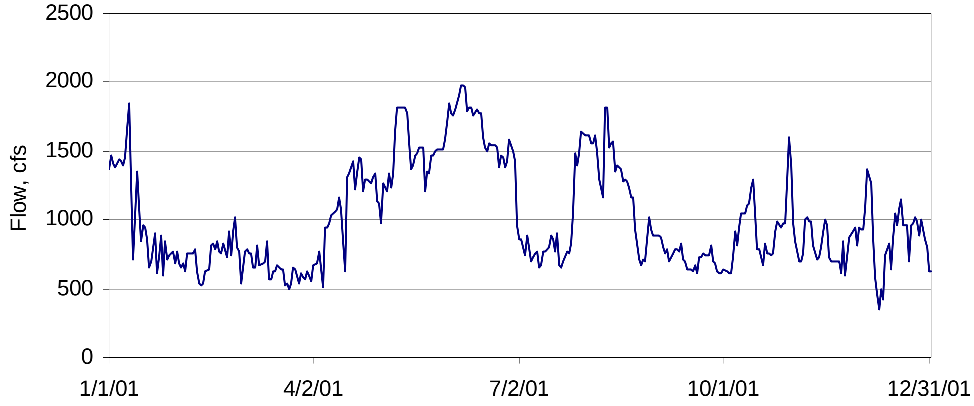
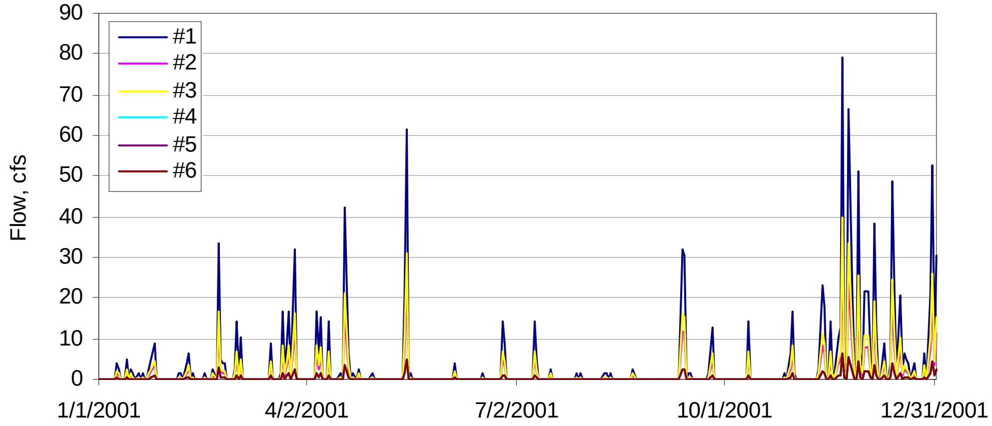


Figure 2. Lake Ewauna inflow at Link River for Lake Ewauna to Keno Dam reach model, 2001

Tributary Inflows



(a)

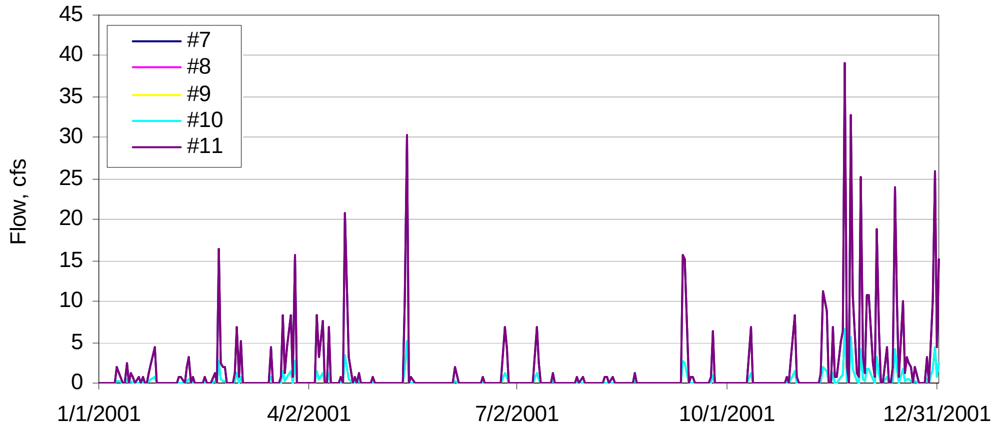


Figure 3. Storm water runoff flow for Lake Ewauna to Keno Dam reach model: (a) Runoff input locations #1 through #6, (b) Runoff input locations #7 through #11

Columbia Plywood

Table 15. Columbia Plywood inflow temperatures for Lake Ewauna to Keno Dam reach model, 2001

Julian Day	Inflow Temperature, C
1	13.61
15	13.33
46	13.89
74	14.44
105	16.11
135	17.22
166	18.89
196	21.11
227	20.56
258	18.33
288	15.56
319	13.33
349	13.89
366	13.61

Klamath Falls Water Treatment Plant

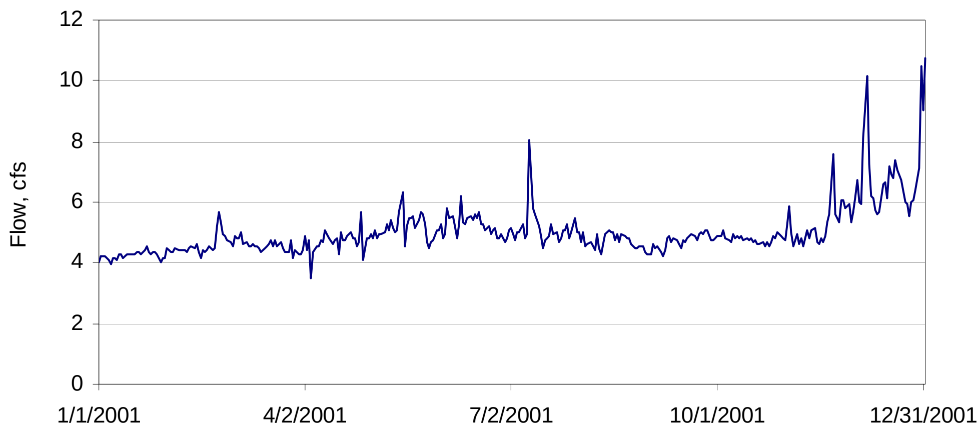


Figure 4. Klamath Falls Wastewater Treatment Plant for Lake Ewauna to Keno Dam reach model, 2001

South Suburban Sanitation District

Table 2. South Suburban Sanitation District flow for Lake Ewauan to Keno Dam reach model, 2001

Julian Day	Flow, cfs
1	3.11
15	2.98
46	2.69
75	3.00
106	2.68
136	0.86
167	0.96
197	1.03
228	1.58
259	2.18
289	2.06
320	2.46
350	4.92
366	5.09

Collins Forest Products

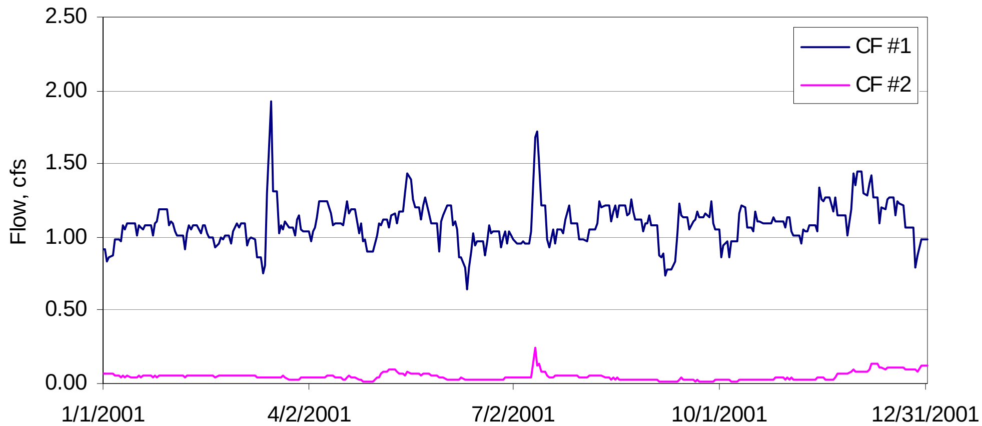


Figure 5. Collins Forest Product flows #1 and #2 for Lake Ewauna to Keno Dam reach model

Lost River Diversion Channel

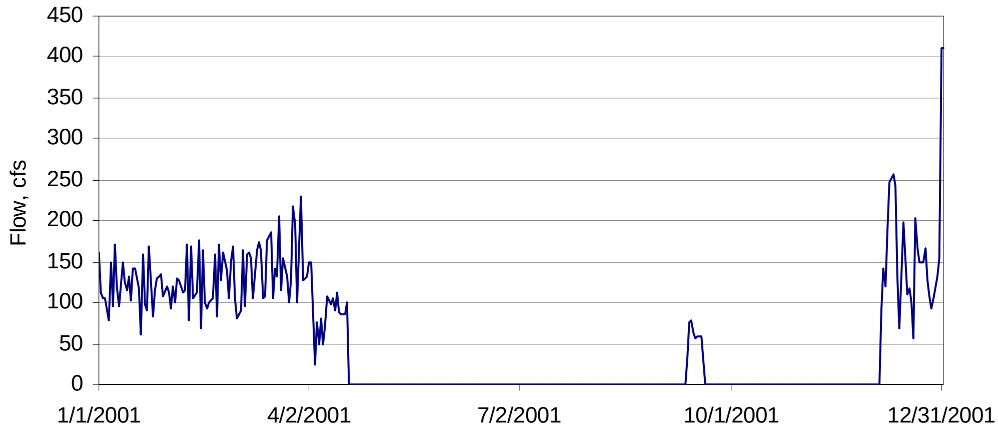


Figure 6. Lost River Diversion Channel inflows to Lake Ewauna for Lake Ewauna to Keno Dam reach model

Klamath Straits Drain

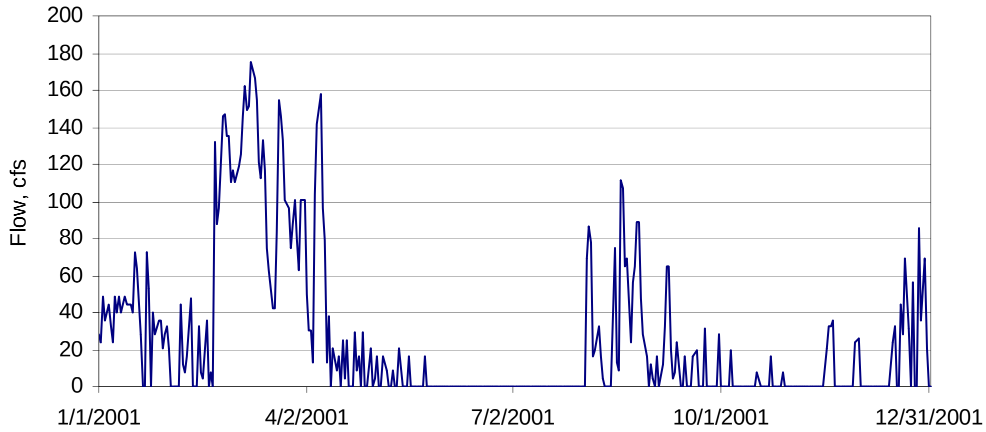


Figure 7. Klamath Straits Drain flow for Lake Ewauna to Keno Dam reach model

Withdrawals

Klamath Reclamation Project Diversions

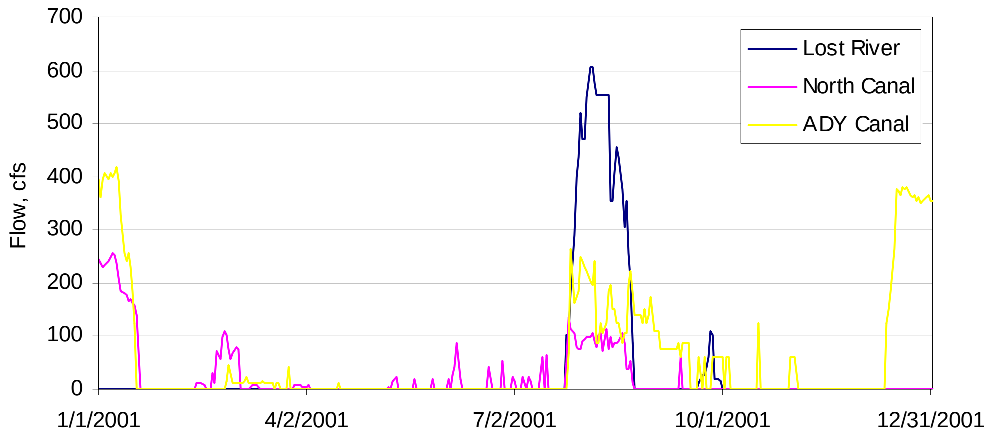


Figure 8. Klamath reclamation project diversions for Lake Ewauna to Keno Dam reach model, 2001

Non-Reclamation Irrigation Diversions

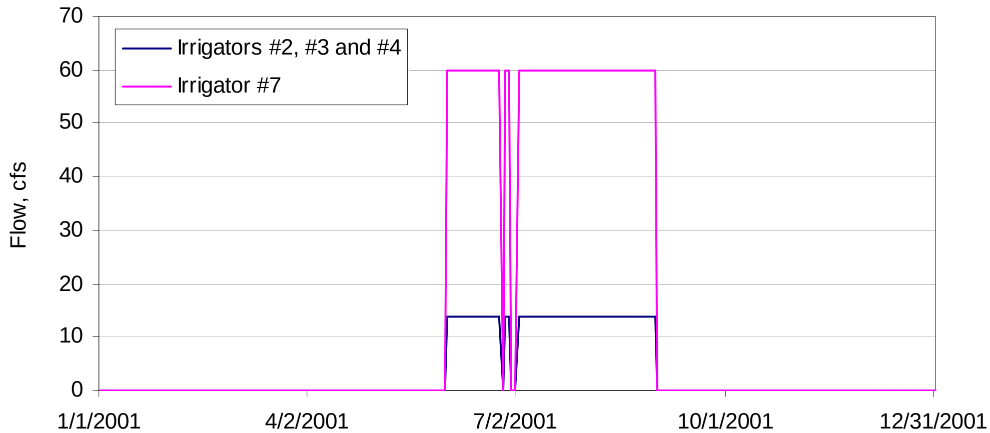


Figure 9. Irrigator withdrawals for Lake Ewauna to Keno Dam reach model, 2001

Keno Dam Outflow

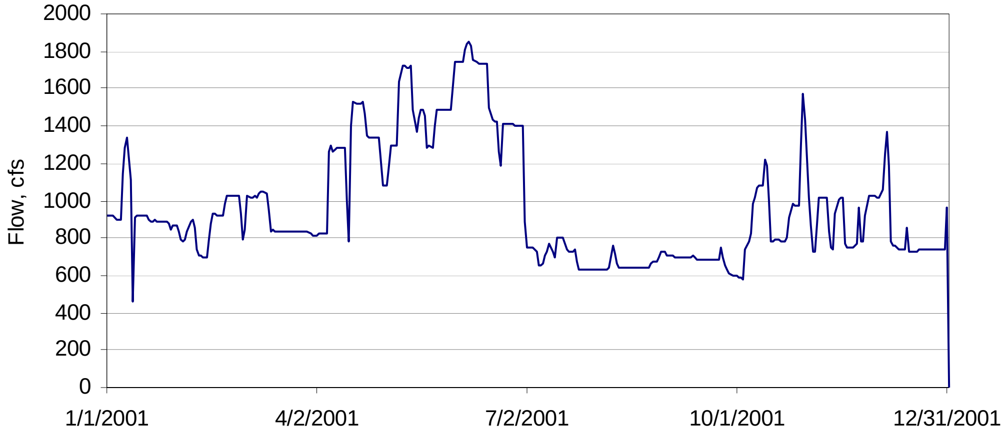


Figure 10. Keno Dam outflow for Lake Ewauna to Keno Dam reach model, 2001

Accretion/Depletion

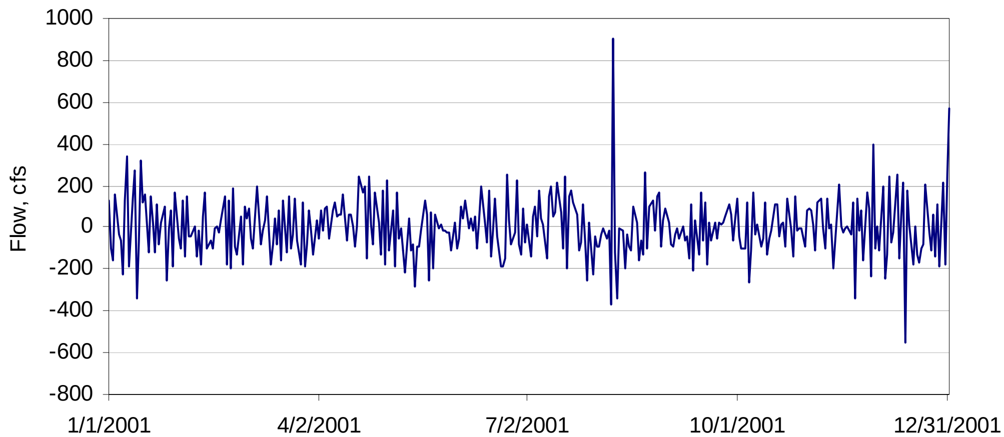


Figure 11. Accretion / depletion flow (distributed tributary) for Lake Ewauna to Keno Dam reach model, 2001

Tributary Temperatures

Klamath Falls Wastewater Treatment Plant Inflow Temperatures

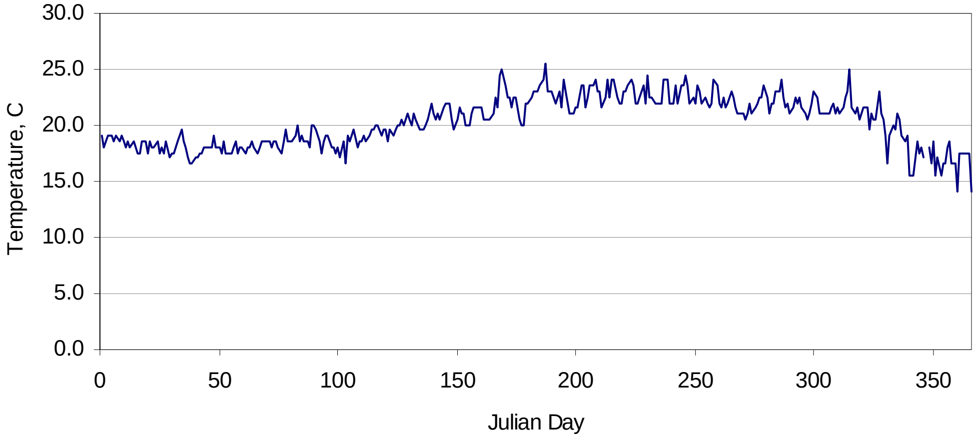


Figure 12. Klamath Falls Wastewater Treatment Plant inflow temperatures for Lake Ewauna to Keno Dam reach model

South Suburban Inflow Temperatures

Table 3. South Suburban Sanitation District inflow temperatures for Lake Ewauna to Keno Dam reach model implementation

Julian Day	Inflow Temperature, C
1	3.5
15	2.7
46	2.6
75	7.4
106	10.0
136	14.7
167	17.0
197	20.3
228	20.6
259	17.1
289	11.3
320	5.3
350	1.0
366	2.2

Lost River Inflow Temperatures

Table 4. Lost River Diversion inflow temperatures for Lake Ewauna to Keno Dam reach model

Julian Day	Inflow Temperature, C
1	3.62
4	3.62
17	1.74
37	5.95
52	5.20
66	7.98
192	26.21
205	25.19
221	26.75
235	18.28
247	20.48
275	19.42
289	12.62
303	9.22
317	7.14
366	7.14

Collins Forest Products Inflow Temperatures

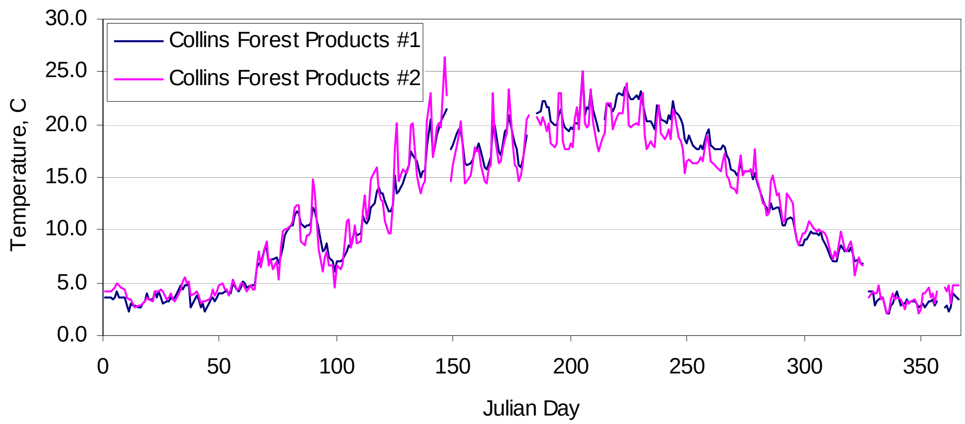


Figure 13. Collins Forest Products #1 and #2 inflow temperature for Lake Ewauna to Keno Dam reach model

Klamath Straits Drain Inflow Temperatures

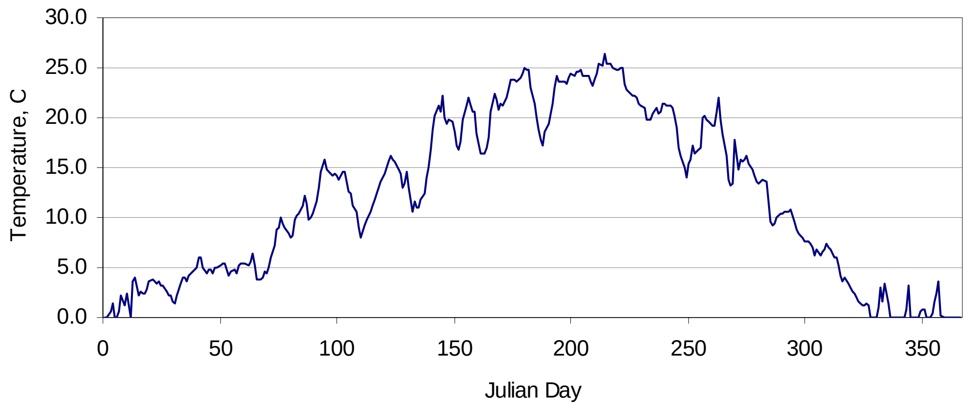


Figure 14. Klamath Straits Drain inflow temperatures for Lake Ewauna to Keno Dam reach model

Tributary Water Quality

Klamath Falls Wastewater Treatment Plant

Table 5. KFWTP inflow concentrations for the Lake Ewauna-Keno Reach

Julian Day	Total Dissolved Solids, mg/l	Tracer, mg/l	Suspended Solids, mg/l	Phosphate, mg/l	Ammonia, mg/l	Nitrate-Nitrite, mg/l	Iron, mg/l	Labile Dissolved Organic Matter, mg/l	Refractory Dissolved Organic Matter, mg/l	BOD_5, mg/l	Algae, mg/l	Dissolved Oxygen, mg/l	Total Inorganic Carbon, mg/l	Alkalinity, meq/l
1	200.0	0.0	4.0	3.0	6.0	1.5	0.0	0.0	0.0	14.0	0.0	3.9	14.0	50.0
15	200.0	0.0	9.3	3.0	6.0	1.5	0.0	0.0	0.0	9.1	0.0	4.5	14.0	50.0
46	200.0	0.0	14.4	3.0	6.0	1.5	0.0	0.0	0.0	9.6	0.0	4.6	14.0	50.0
74	200.0	0.0	25.6	3.0	6.0	1.5	0.0	0.0	0.0	30.5	0.0	4.2	14.0	50.0
105	200.0	0.0	13.5	3.0	6.0	1.5	0.0	0.0	0.0	12.3	0.0	4.6	14.0	50.0
135	200.0	0.0	5.5	3.0	6.0	1.5	0.0	0.0	0.0	3.9	0.0	4.5	14.0	50.0
166	200.0	0.0	6.1	3.0	6.0	1.5	0.0	0.0	0.0	3.4	0.0	4.4	14.0	50.0
196	200.0	0.0	3.5	3.0	6.0	1.5	0.0	0.0	0.0	3.0	0.0	4.1	14.0	50.0
227	200.0	0.0	5.7	3.0	6.0	1.5	0.0	0.0	0.0	3.5	0.0	3.8	14.0	50.0
258	200.0	0.0	2.4	3.0	6.0	1.5	0.0	0.0	0.0	3.5	0.0	3.8	14.0	50.0
288	200.0	0.0	3.1	3.0	6.0	1.5	0.0	0.0	0.0	7.1	0.0	4.3	14.0	50.0
319	200.0	0.0	3.4	3.0	6.0	1.5	0.0	0.0	0.0	3.1	0.0	4.5	14.0	50.0
349	200.0	0.0	2.3	3.0	6.0	1.5	0.0	0.0	0.0	3.4	0.0	4.1	14.0	50.0
366	200.0	0.0	3.0	3.0	6.0	1.5	0.0	0.0	0.0	2.0	0.0	5.0	14.0	50.0

South Side Sanitation District

Table 6. SSSD inflow concentrations for the Lake Ewauna-Keno Reach

Julian Day	Total Dissolved Solids, mg/l	Tracer, mg/l	Suspended Solids, mg/l	Phosphate, mg/l	Ammonia, mg/l	Nitrate-Nitrite, mg/l	Iron, mg/l	Labile Dissolved Organic Matter, mg/l	Refractory Dissolved Organic Matter, mg/l	BOD_5, mg/l	Algae, mg/l	Dissolved Oxygen, mg/l	Total Inorganic Carbon, mg/l	Alkalinity, meq/l
1	200.0	0.0	42.5	0.0	9.4	0.0	0.0	0.0	0.0	28.6	0.0	15.0	0.0	61.2
15	200.0	0.0	73.8	0.0	11.5	0.0	0.0	0.0	0.0	26.6	0.0	14.0	0.0	41.1
46	200.0	0.0	80.9	0.0	21.0	0.0	0.0	0.0	0.0	28.6	0.0	12.5	0.0	37.2
75	200.0	0.0	50.9	0.0	18.0	0.0	0.0	0.0	0.0	30.7	0.0	7.9	0.0	21.7
106	200.0	0.0	26.8	0.0	25.0	0.0	0.0	0.0	0.0	28.0	0.0	3.8	0.0	8.6
136	200.0	0.0	30.5	2.8	15.0	0.2	0.0	0.0	0.0	30.3	0.0	4.7	0.0	11.5
167	200.0	0.0	45.2	1.9	5.5	2.0	0.0	0.0	0.0	30.4	0.0	4.8	0.0	8.6
197	200.0	0.0	37.8	2.5	2.8	1.3	0.0	0.0	0.0	28.9	0.0	4.5	0.0	10.6
228	200.0	0.0	46.5	2.7	6.3	0.3	0.0	0.0	0.0	25.9	0.0	5.4	0.0	41.5
259	200.0	0.0	70.0	2.2	8.8	1.7	0.0	0.0	0.0	42.9	0.0	6.0	0.0	74.2
289	200.0	0.0	38.8	2.2	3.3	0.6	0.0	0.0	0.0	33.9	0.0	7.9	0.0	75.6
320	200.0	0.0	30.9	0.0	6.5	0.0	0.0	0.0	0.0	35.6	0.0	10.3	0.0	37.1
350	200.0	0.0	30.6	0.0	4.5	0.0	0.0	0.0	0.0	30.7	0.0	13.8	0.0	67.6
366	200.0	0.0	42.5	0.0	9.4	0.0	0.0	0.0	0.0	28.6	0.0	12.1	0.0	30.6

Lost River Diversion Channel

Table 7. Wilson Reservoir 2001 Data

Julian Day	Total Dissolved Solids, mg/l	Tracer, mg/l	Suspended Solids, mg/l	Phosphate, mg/l	Ammonia, mg/l	Nitrate-Nitrite, mg/l	Iron, mg/l	Labile Dissolved Organic Matter, mg/l	Refractory Dissolved Organic Matter, mg/l	BOD_5, mg/l	Algae, mg/l	Dissolved Oxygen, mg/l	Total Inorganic Carbon, mg/l	Alkalinity, meq/l
1	175.0	0.0	10.0	0.1	0.2	0.5	0.0	0.0	0.0	2.0	0.9	9.7	23.0	140.0
4	175.0	0.0	10.0	0.1	0.2	0.5	0.0	0.0	0.0	2.0	1.0	11.5	23.0	120.0
17	175.0	0.0	10.0	0.1	0.1	0.4	0.0	0.0	0.0	2.0	0.4	13.2	23.0	140.0
37	175.0	0.0	10.0	0.1	0.1	0.3	0.0	0.0	0.0	2.0	0.4	12.1	23.0	140.0
52	175.0	0.0	10.0	0.1	0.2	0.4	0.0	0.0	0.0	2.0	0.4	10.1	23.0	130.0
66	175.0	0.0	10.0	0.1	0.1	0.1	0.0	0.0	0.0	2.0	0.7	10.3	23.0	140.0
192	175.0	0.0	10.0	0.4	0.0	0.2	0.0	0.0	0.0	5.4	1.7	6.7	23.0	132.0
205	175.0	0.0	10.0	0.2	0.0	0.1	0.0	0.0	0.0	5.7	1.0	5.9	23.0	135.0
221	175.0	0.0	10.0	0.3	0.1	0.0	0.0	0.0	0.0	6.2	1.2	8.0	23.0	139.0
235	175.0	0.0	10.0	0.3	0.1	0.3	0.0	0.0	0.0	6.6	1.2	3.8	23.0	132.0
247	175.0	0.0	10.0	0.2	0.0	0.0	0.0	0.0	0.0	6.9	0.8	4.2	23.0	142.0
275	175.0	0.0	10.0	0.1	0.1	0.0	0.0	0.0	0.0	7.7	0.7	7.9	23.0	153.0
289	175.0	0.0	10.0	0.2	0.0	0.0	0.0	0.0	0.0	7.6	0.5	8.9	23.0	164.0
303	175.0	0.0	10.0	0.1	0.1	0.0	0.0	0.0	0.0	6.6	0.1	9.2	23.0	146.0
317	175.0	0.0	10.0	0.1	0.2	0.5	0.0	0.0	0.0	5.6	0.3	9.7	23.0	156.0
366	175.0	0.0	10.0	0.1	0.2	0.5	0.0	0.0	0.0	2.0	0.9	9.7	23.0	150.0

Columbia Plywood

Table 8. Columbia Plywood inflow concentrations for the Lake Ewauna-Keno Reach

Julian Day	Total Dissolved Solids, mg/l	Tracer, mg/l	Suspended Solids, mg/l	Phosphate, mg/l	Ammonia, mg/l	Nitrate-Nitrite, mg/l	Iron, mg/l	Labile Dissolved Organic Matter, mg/l	Refractory Dissolved Organic Matter, mg/l	BOD_5, mg/l	Algae, mg/l	Dissolved Oxygen, mg/l	Total Inorganic Carbon, mg/l	Alkalinity, meq/l
1	25.0	0.0	16.0	0.15	0.15	0.24	0.0	5.0	0.0	8.0	0.0	7.0	15.8	52.0
366	25.0	0.0	16.0	0.15	0.15	0.24	0.0	5.0	0.0	8.0	0.0	7.0	15.8	52.0

Collins Forest Products

Table 9. Collins Forest Products #1 inflow concentrations for the Lake Ewauna-Keno Reach

Julian Day	Total Dissolved Solids, mg/l	Tracer, mg/l	Suspended Solids, mg/l	Phosphate, mg/l	Ammonia, mg/l	Nitrate-Nitrite, mg/l	Iron, mg/l	Labile Dissolved Organic Matter, mg/l	Refractory Dissolved Organic Matter, mg/l	BOD_5, mg/l	Algae, mg/l	Dissolved Oxygen, mg/l	Total Inorganic Carbon, mg/l	Alkalinity, meq/l
1	200.0	0.0	11.6	0.2	0.2	0.2	0.0	0.0	0.0	29.8	0.0	3.5	12.2	50.0
15	200.0	0.0	12.5	0.2	0.2	0.2	0.0	0.0	0.0	34.3	0.0	3.5	12.2	50.0
46	200.0	0.0	14.6	0.2	0.2	0.2	0.0	0.0	0.0	51.4	0.0	3.5	12.2	50.0
75	200.0	0.0	19.9	0.2	0.2	0.2	0.0	0.0	0.0	38.8	0.0	3.5	12.2	50.0
106	200.0	0.0	12.1	0.2	0.2	0.2	0.0	0.0	0.0	32.1	0.0	3.5	12.2	50.0
136	200.0	0.0	6.6	0.2	0.2	0.2	0.0	0.0	0.0	18.7	0.0	3.5	12.2	50.0
167	200.0	0.0	8.0	0.2	0.2	0.2	0.0	0.0	0.0	11.1	0.0	3.5	12.2	50.0
197	200.0	0.0	6.2	0.2	0.2	0.2	0.0	0.0	0.0	10.6	0.0	3.5	12.2	50.0
228	200.0	0.0	2.3	0.2	0.2	0.2	0.0	0.0	0.0	7.2	0.0	3.5	12.2	50.0
259	200.0	0.0	2.6	0.2	0.2	0.2	0.0	0.0	0.0	9.5	0.0	3.5	12.2	50.0
289	200.0	0.0	18.4	0.2	0.2	0.2	0.0	0.0	0.0	18.8	0.0	3.5	12.2	50.0
320	200.0	0.0	28.6	0.2	0.2	0.2	0.0	0.0	0.0	27.8	0.0	3.5	12.2	50.0
350	200.0	0.0	34.9	0.2	0.2	0.2	0.0	0.0	0.0	28.5	0.0	3.5	12.2	50.0
366	200.0	0.0	11.6	0.2	0.2	0.2	0.0	0.0	0.0	29.8	0.0	3.5	12.2	50.0

Table 10. Collins Forest Products #2 concentrations for the Lake Ewauna-Keno Reach

Julian Day	Total Dissolved Solids, mg/l	Tracer, mg/l	Suspended Solids, mg/l	Phosphate, mg/l	Ammonia, mg/l	Nitrate-Nitrite, mg/l	Iron, mg/l	Labile Dissolved Organic Matter, mg/l	Refractory Dissolved Organic Matter, mg/l	BOD_5, mg/l	Algae, mg/l	Dissolved Oxygen, mg/l	Total Inorganic Carbon, mg/l	Alkalinity, meq/l
1	200.0	0.0	20.7	3.0	3.0	0.5	0.0	0.0	0.0	15.0	0.0	3.5	11.9	50.0
15	200.0	0.0	32.5	3.0	3.0	0.5	0.0	0.0	0.0	12.6	0.0	3.5	11.9	50.0
46	200.0	0.0	42.5	3.0	3.0	0.5	0.0	0.0	0.0	17.1	0.0	3.5	11.9	50.0
75	200.0	0.0	38.0	3.0	3.0	0.5	0.0	0.0	0.0	18.1	0.0	3.5	11.9	50.0
106	200.0	0.0	35.8	3.0	3.0	0.5	0.0	0.0	0.0	23.6	0.0	3.5	11.9	50.0
136	200.0	0.0	24.3	3.0	3.0	0.5	0.0	0.0	0.0	14.1	0.0	3.5	11.9	50.0
167	200.0	0.0	5.3	3.0	3.0	0.5	0.0	0.0	0.0	5.9	0.0	3.5	11.9	50.0
197	200.0	0.0	7.6	3.0	3.0	0.5	0.0	0.0	0.0	7.6	0.0	3.5	11.9	50.0
228	200.0	0.0	3.2	3.0	3.0	0.5	0.0	0.0	0.0	6.3	0.0	3.5	11.9	50.0
259	200.0	0.0	2.9	3.0	3.0	0.5	0.0	0.0	0.0	8.0	0.0	3.5	11.9	50.0
289	200.0	0.0	2.1	3.0	3.0	0.5	0.0	0.0	0.0	5.1	0.0	3.5	11.9	50.0
320	200.0	0.0	10.9	3.0	3.0	0.5	0.0	0.0	0.0	8.0	0.0	3.5	11.9	50.0
350	200.0	0.0	31.1	3.0	3.0	0.5	0.0	0.0	0.0	16.1	0.0	3.5	11.9	50.0
366	200.0	0.0	20.7	3.0	3.0	0.5	0.0	0.0	0.0	15.0	0.0	3.5	11.9	50.0

Klamath Straits Drain

Table 16. KSD inflow concentrations for the Lake Ewauna-Keno Reach

Julian Day	Total Dissolved Solids, mg/l	Tracer, mg/l	Suspended Solids, mg/l	Phosphate, mg/l	Ammonia, mg/l	Nitrate-Nitrite, mg/l	Iron, mg/l	Labile Dissolved Organic Matter, mg/l	Refractory Dissolved Organic Matter, mg/l	BOD_5, mg/l	Algae, mg/l	Dissolved Oxygen, mg/l	Total Inorganic Carbon, mg/l	Alkalinity, meq/l
1	354.0	0.0	24.0	0.1	0.3	0.3	0.0	10.0	0.0	5.0	1.0	9.0	37.0	150.0
15	374.0	0.0	24.0	0.1	0.3	0.3	0.0	10.0	0.0	5.0	1.0	9.0	37.0	150.0
46	316.0	0.0	24.0	0.2	0.3	0.3	0.0	10.0	0.0	5.0	1.0	9.0	37.0	150.0
75	365.0	0.0	24.0	0.2	0.3	0.3	0.0	10.0	0.0	5.0	1.0	9.0	37.0	150.0
106	409.0	0.0	24.0	0.4	0.3	0.5	0.0	10.0	0.0	5.0	1.0	4.7	37.0	150.0
136	423.0	0.0	24.0	0.5	0.5	0.5	0.0	13.0	0.0	5.0	1.0	6.8	37.0	150.0
167	319.0	0.0	24.0	0.5	0.5	0.5	0.0	15.0	0.0	5.0	1.0	3.5	37.0	150.0
197	266.0	0.0	24.0	0.5	0.5	1.0	0.0	15.0	0.0	5.0	1.0	2.4	37.0	150.0
228	252.0	0.0	24.0	0.3	0.5	1.3	0.0	13.0	0.0	5.0	1.0	1.9	37.0	150.0
259	296.0	0.0	24.0	0.2	1.0	2.0	0.0	10.0	0.0	5.0	1.0	2.8	37.0	150.0
289	376.0	0.0	24.0	0.2	1.5	0.3	0.0	10.0	0.0	5.0	1.0	3.3	37.0	150.0
320	294.0	0.0	24.0	0.1	0.3	0.3	0.0	10.0	0.0	5.0	1.0	9.1	37.0	150.0
350	334.0	0.0	24.0	0.1	0.3	0.3	0.0	10.0	0.0	5.0	1.0	9.0	37.0	150.0
366	354.0	0.0	24.0	0.1	0.3	0.3	0.0	10.0	0.0	5.0	1.0	9.0	37.0	150.0

Distributed Tributary

Table 12. Distributed tributary concentrations for the Lake Ewauna-Keno Reach

Julian Day	Total Dissolved Solids, mg/l	Tracer, mg/l	Suspended Solids, mg/l	Phosphate, mg/l	Ammonia, mg/l	Nitrate-Nitrite, mg/l	Iron, mg/l	Labile Dissolved Organic Matter, mg/l	Refractory Dissolved Organic Matter, mg/l	BOD_5, mg/l	Algae, mg/l	Dissolved Oxygen, mg/l	Total Inorganic Carbon, mg/l	Alkalinity, meq/l
1	25.0	0.0	0.0	0.1	0.05	1.0	0.0	0.0	0.0	1.0	0.0	3.0	20.2	80.0
274	25.0	0.0	0.6	0.1	0.05	1.0	0.0	0.0	0.0	1.0	0.0	3.0	20.2	80.0
366	25.0	0.0	0.6	0.1	0.05	1.0	0.0	0.0	0.0	1.0	0.0	3.0	20.2	80.0

“Tracer” is a conservative constituent that does not decay or react with time or space. Can be used to check conservation of mass within the model framework.

Stormwater Runoff

Table 13. Storm water runoff concentrations for the Lake Ewauna-Keno Reach

Julian Day	Total Dissolved Solids, mg/l	Tracer, mg/l	Suspended Solids, mg/l	Phosphate, mg/l	Ammonia, mg/l	Nitrate-Nitrite, mg/l	Iron, mg/l	Labile Dissolved Organic Matter, mg/l	Refractory Dissolved Organic Matter, mg/l	BOD_5, mg/l	Algae, mg/l	Dissolved Oxygen, mg/l	Total Inorganic Carbon, mg/l	Alkalinity, meq/l
1	25.0	0.0	5.0	0.05	0.05	0.1	0.0	3.0	0.0	0.7	0.0	9.0	15.9	52.0
366	25.0	0.0	5.0	0.05	0.05	0.1	0.0	3.0	0.0	0.7	0.0	9.0	15.9	52.0